GENERAL ELECTRIC REVIEW

A MONTHLY MAGAZINE FOR ENGINEERS

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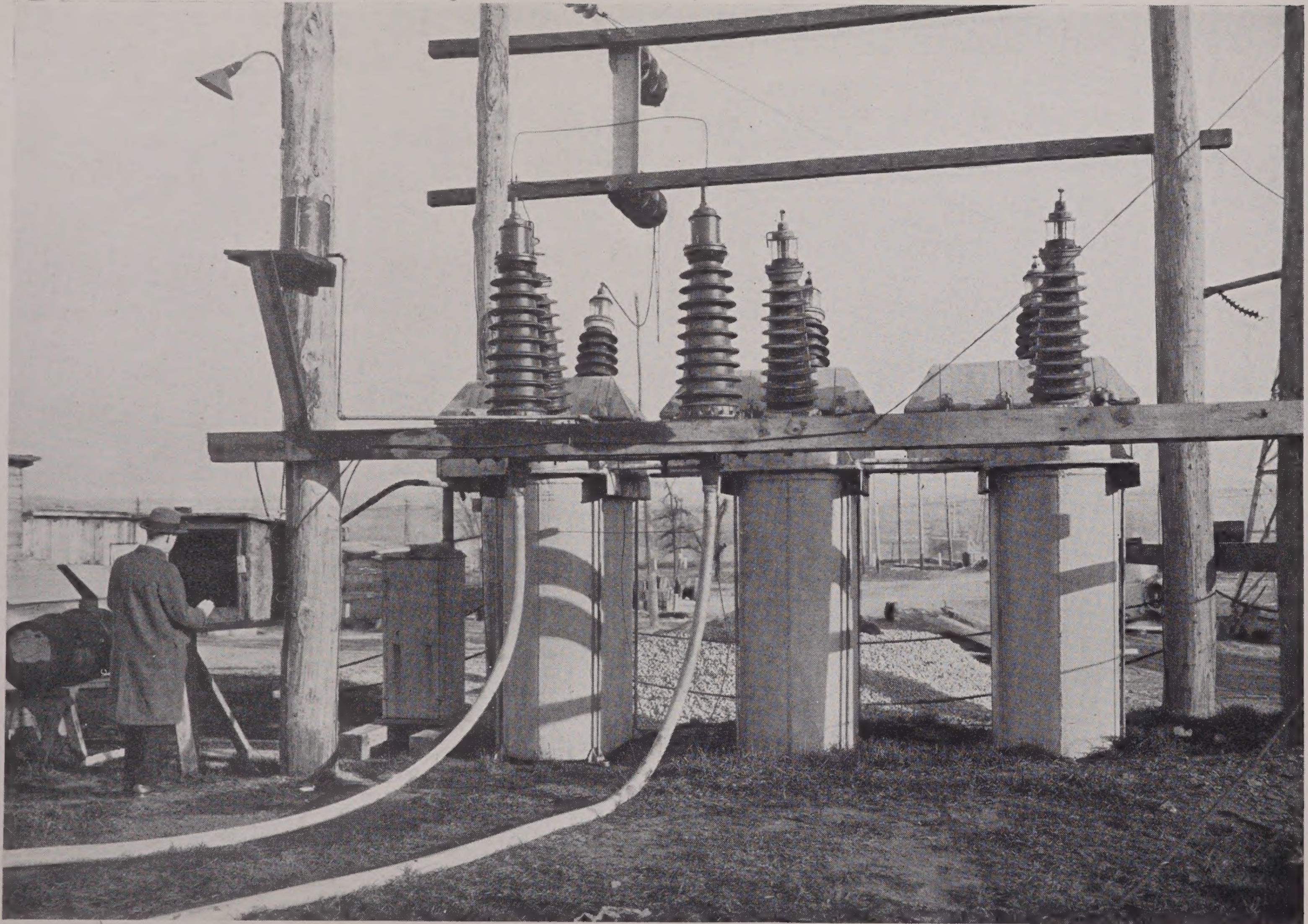

A Section of Recently Developed Underground Cable, with Impregnated Paper Insulation, Under Field Test on a 110,000-volt Circuit at the Albany Switching Station of the Adirondack Power and Light Corporation. (*See article p. 4*)

GENERAL ELECTRIC REVIEW

AGAIN WE LOOK BACKWARD

As the surveyor when running a line of sight turns backward periodically to check his bearings before aligning his transit for a foresight, we of the electrical profession can lay out our line of future progress more intelligently if we occasionally turn backward to review the events we are leaving. Thus again in our January issue we continue the practice we originated eleven years ago of giving a simple and unembellished summary of developments that stand out prominently among the many others made in the electrical industry during the preceding year.

This record of achievements is of interest not only to the manufacturer's scientists and engineers, but to salesmen, purchasers, and operators. Each of these branches of the electrical fraternity has members who have helped in one way or another to bring about the year's development—possibly by discovering some hitherto unknown principle or the means of taming some formerly unmanageable phenomenon, perhaps by inventing a new device or adapting an existing device to a new purpose, or, again, by enlarging some device on a grander scale or redesigning it to deliver a greater output per pound and per dollar. Then, too, we must not fail to give credit to those who have matched courage with the money necessary to produce a major accomplishment, nor forget those whose only contribution was the realizing of a need and the furnishing of helpful data to those in a better position to complete the work.

The summary also holds interest for the student, because it is of the nature of an engineering appendix that brings strictly up-to-date the text books on engineering practice which he is studying.

While such a review of accomplishments always makes *interesting* reading, it is not for this reason alone that we practically fill this issue with its record. Neither is it to pat ourselves on the back and say: "We did this, or we did that." Any enjoyment of such self gratification would be but short lived because advances are being made so rapidly that the newness or novelty of today's development becomes the commonplace of tomorrow. The following pages present but the summary of one year's initiative and response by a large manufacturer of electrical apparatus, in close co-operation with producers and consumers of electricity, to further that progress which electricity has already made in increasing our economic wealth and in bringing to us undreamed of comforts.

The more useful purpose and our real motive in publishing this article was referred to in the opening paragraph. So diversified have become the activities of those working with electricity that some such annual inventory is needed to acquaint each with what the others are doing or have just done. We hope it will also serve to stimulate further progress and to promote the co-operation that comes from the origin and exchange of ideas. Not infrequently an idea that was developed and employed for one purpose has been found to be exceptionally useful for another purpose; in fact, a striking example of this occurred last year.

Specific reference to any advance during 1924 is purposely avoided in this editorial, that by such omission of detail we can better preserve a vision of the whole and in conclusion emphasize the fact that none of us must slacken in the swift pace set us years ago by the pioneers in commercial electrical development. Unbounded possibilities still lie before the whole electrical industry, and only by intensively continuing to explore them and to reduce them to utility will we truly serve our art and the public, remembering that it is from these that we ultimately derive our satisfaction and rewards.

Some Developments in the Electrical Industry During 1924

By John Liston
Publicity Department, General Electric Company

Our practice of including in the first issue of each year a review of the prominent developments in the electrical industry during the previous twelve months has become one of the world-wide features of this magazine. Having devoted our leading editorial of this month to the subject, Mr. Liston's annual review needs no further comment than to say that a reading will show that the electrical industry has made a very creditable record during this period.—Editor.

The total volume of sales for the electrical industry during the year was somewhat below that of 1923, but for certain important classes of apparatus including central-station equipment, automatic stations, traffic signalling, street lighting, and industrial heating, it exceeded all previous records.

While most of the developments were along conventional lines, numerous detailed improvements were made which rendered possible increased efficiency in the generation, conversion, transmission, distribution, and utilization of electric energy. Some of these improvements were of such a character as to constitute definite advances in the art.

In addition to the production of steam turbine-generators of large unit capacity, there was an increase in the use of higher steam temperatures and pressures. The installation of the 65,000-kv-a. waterwheel generators at Niagara was completed and they still represent the maximum in generator unit capacity and physical dimensions.

An important event in transportation was the adoption of a design of electric locomotive to operate from alternating-current feeders with direct-current driving motors. A practicable oil-electric freight locomotive was built and tested in actual service under a variety of operating conditions. The adoption

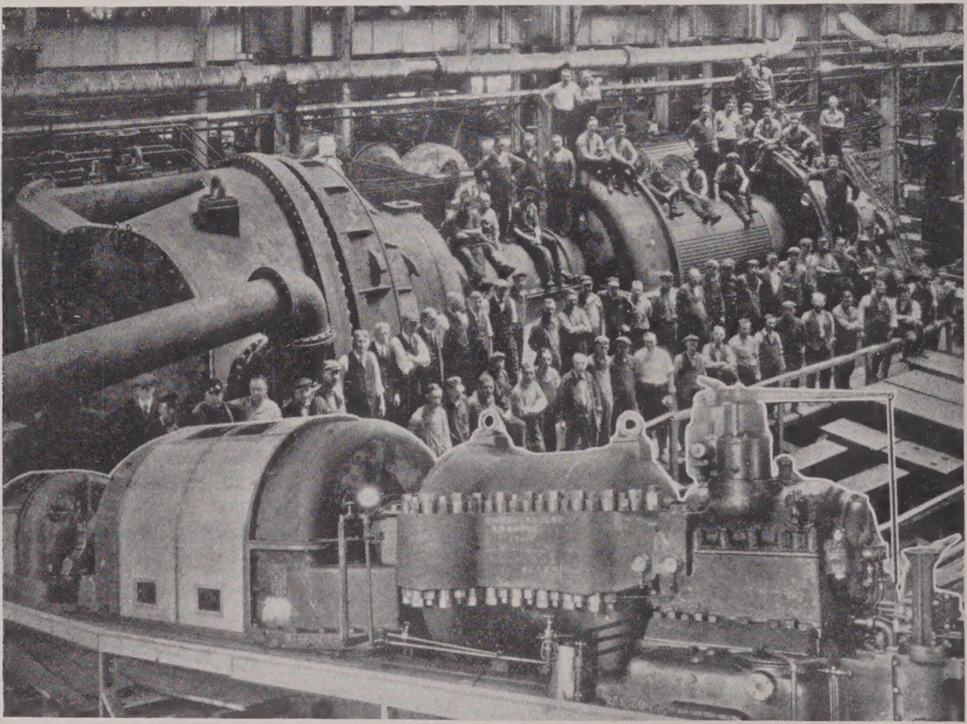

Fig. 1. View in Turbine Testing Department, Showing a 60,000-kw. Compound Steam Turbine-generator for the Commonwealth Edison Company

of light-weight equipment and multiple-car operation for street railways was extended; and gasoline-electric buses were developed for feeder service to established railway lines.

Both the unit capacity and number of installations of automatic station equipment for railroad, hydro-electric, central station, and industrial service were increased as compared with previous years; and there were numerous additions to the line of relays which rendered possible this great economic advance in operating practice.

The growing necessity for high-tension underground conductors was responsible for intensive developmental work not only on conductor cables and their insulation but on the terminals, junction boxes, etc., necessary for a complete dependable underground transmission system.

Research work with the lightning generator was continued and valuable data were secured in regard to the protection of transmission lines. A new x-ray portable outfit was produced; and the manufacture of clear fused quartz on a commercial basis was achieved.

Street lighting installations were made on a larger scale and with higher intensity units than in preceding years; highway lighting was further extended; and the attempts to solve the problem of street-traffic control resulted in the production of a number of illuminated signal standards for both manual and automatic operation.

As in previous articles on this subject, the electrical apparatus, turbines, etc., referred to, are all products of the General Electric Company, but references to their development will serve as an indication of the tendencies in design and construction as well as the general trend of progress in the electrical manufacturing industry as a whole.

TURBINES

The aggregate kilowatt capacity of steam turbines completed and shipped during the year exceeded all previous records.

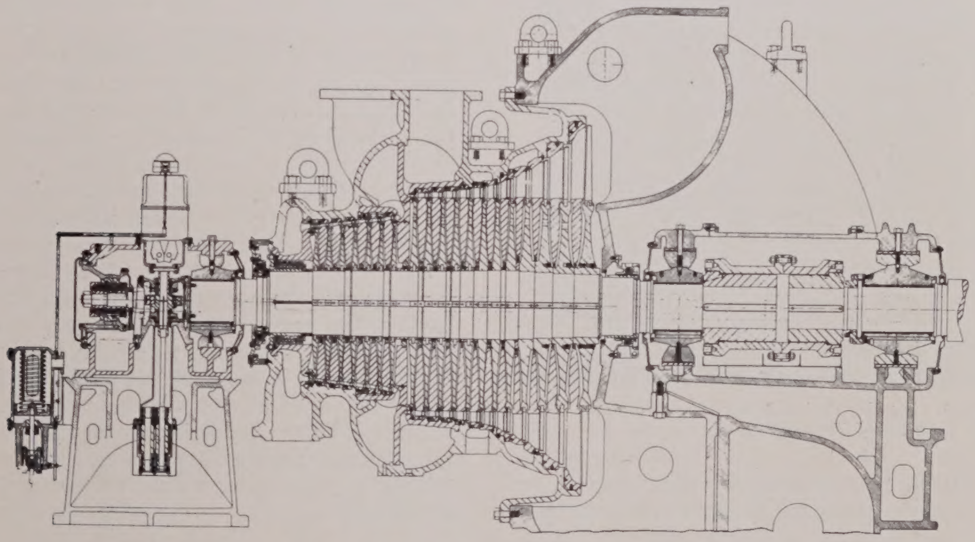

Fig. 2. Section of the Turbine of a 35,000-kw. Single-cylinder Steam Turbine-generator for 550-lb. Steam Pressure and 750 Deg. F. Total Temperature

Among the large machines completed and placed in service was one rated at 60,000 kw., Fig. 1, consisting of a high-pressure and a low-pressure unit, each driving individual generators.

The first 35,000-kw. single-cylinder turbine, Fig. 2, designed for 550 lb. steam pressure and 750 deg. F. total temperature, was placed in commercial service in the Philo Station of the American Gas and Electric Company.

Two machines for operation under conditions similar to the 60,000-kw. unit were under construction. These machines differ from the larger two-cylinder machines in that they do not drive individual generators, but both cylinders are coupled to a single 40,000-kw. generator.

The first turbine designed for operation with a steam pressure of 1200 lb., Fig. 3, is under construction in the shops. The high operating pressure involved unusually heavy mechanical construction for the turbine casing.

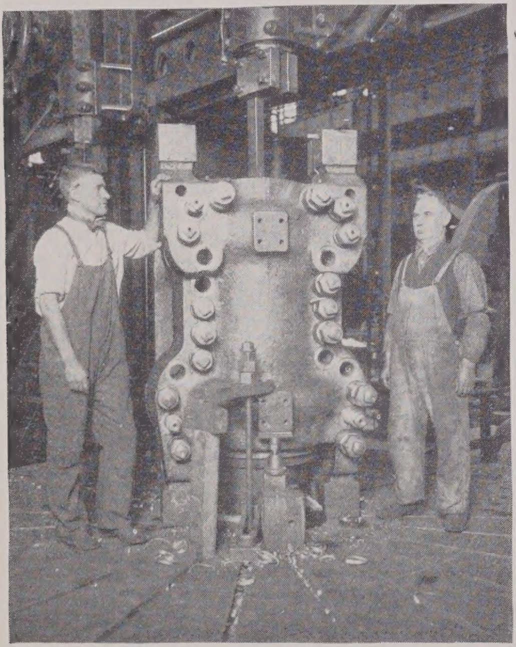

Fig. 3. Massive Casing Construction Required for 1200-lb. Pressure Steam Turbine

Among the large high-speed machines under construction were some rated at 50,000 kw., 62,500 kv-a., 1800 r.p.m. The production of machines of this capacity and speed has been rendered possible by the use of twisted conductors in the armature windings and improved methods of rotor construction. Other machines of exceptional capacity include 60,000-kw., 60,000-kv-a., 1500-r.p.m. units. All of these large machines when completed will represent maximum capacities for the speeds at which they operate.

The Emmet mercury turbine and boiler installation made for the Hartford Electric Light Company, Hartford, Conn., attracted a great deal of attention and the success achieved during one year of operation was very gratifying to all concerned. Experience indicated that certain improvements in details can, to advantage, be made and the necessary changes are now being carried out.

SUPERCHARGER

A new type of supercharger known as the "Side Type" was developed for 20,000-ft. altitude operation. On the airplane it is located at the side of the engine instead of at the nose of the plane between the propeller and engine where previous types have been located.

In the original supercharger, the turbine wheel was located between the compressor and the nozzle box, which gave a somewhat restricted passage for the exhaust gases, but in the new outfit, Fig. 4, the nozzle box is located on the outside of the centrifugal compressor, thereby permitting the operation of the turbine wheel in the outside atmosphere and the discharge of the exhaust gases into the stream of air back of the propeller. This arrangement carries the exhaust gases out of the way of the aviator, eliminates gas straying into the cockpit and gives improved cooling for the turbine wheel.

In all airplane work it is exceedingly important to decrease the weight of all of the apparatus, and this has been borne in mind in the various stages of supercharger design. The original nose-type supercharger, developed during the war, added 150 lb. to the weight of the plane, whereas the side-type supercharger adds only 100 lb., a great many of the parts being made of aluminum and duralumin.

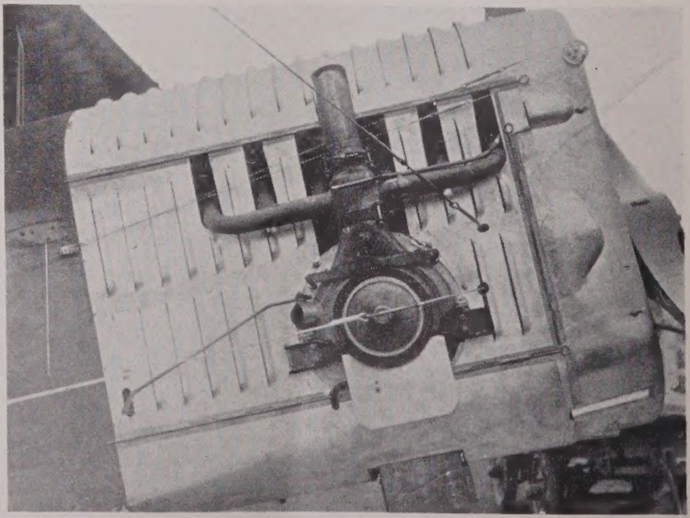

Fig. 4. New Type of Side-mounted Airplane Supercharger

A geared supercharger for 7500-ft. altitude was also developed and due to the small size and refined design, and the nature of the material used in the impeller, it was possible to develop a drive to withstand the severe acceleration conditions involved.

The metal magnesium, which has two-thirds the density of aluminum, was used for the construction of supercharger compressors, thereby effecting a considerable reduction in weight, Fig. 5, as compared with even the lightest suitable materials previously utilized for this purpose. Magnesium is beginning to occupy a definite place as an engineering material as it can now be obtained in commercial quantities.

ELECTRIC PROPULSION

Three combined tug and fire boats, Fig. 6, and one reconverted tanker were equipped with Diesel-engine-electric propelling machinery, all being owned by the Atlantic Refining Company. The tug and fire boats are intended for towing oil barges between Philadelphia and Massachusetts ports, and the tanker for general service.

The tug and fire boats are 97 ft. overall, beam 27 ft., moulded depth 11 ft. 6 in., and speed 10 knots. The propelling machinery of all four vessels, Fig. 7, consists of two 4-cycle engines of 225 b.h.p. each, each direct connected to a 155-kw., 125-volt direct-current generator, and having a 26-kw. direct-connected exciter. The 250-volt, 375-h.p. propelling motor, which is direct connected to the propeller shaft, operates at 120 r.p.m.

The Ward Leonard system of variable field excitation control is used when propelling the boats; but when the generators are used for driving the fire pumps or operating pumps on barges alongside, the Ward Leonard system is disconnected and fixed excitation applied, so that the generators operate at constant voltage. All the auxiliaries of each ship are driven from one exciter, the other exciter acting as a standby.

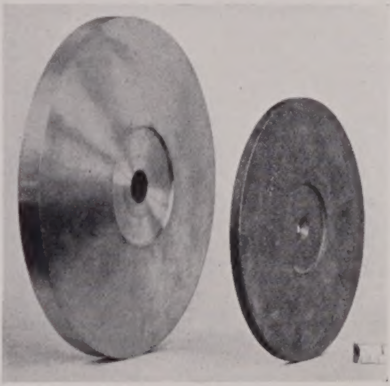

Fig. 5. Magnesium and Brass Disks of Identical Weight

In addition to the foregoing, repeat orders were received for propulsion and control equipments for a third Golden Gate ferry-boat and a third Standard Oil tanker. Propelling equipment was also completed for the

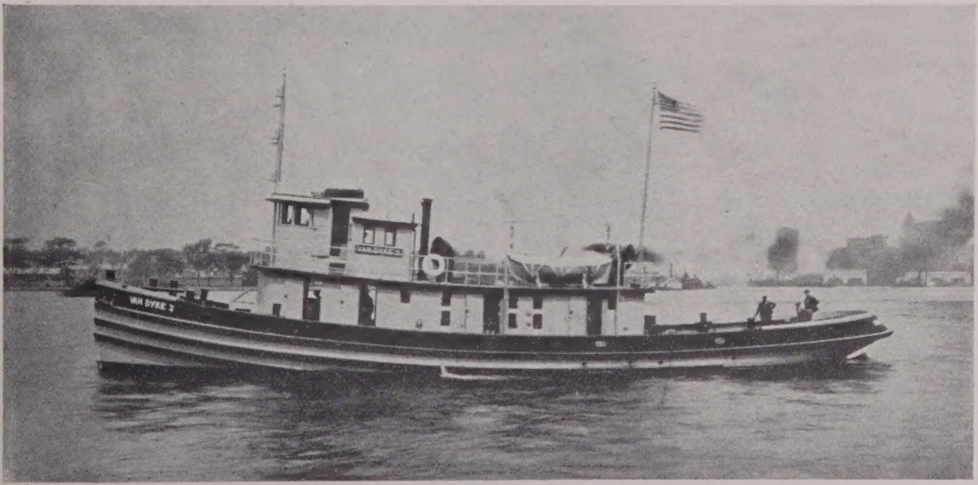

Fig. 6. Combined Tug and Fire Boat Equipped with Diesel-engine-electric Propelling Machinery

first Diesel-engine-electric dredge for operation on the Great Lakes.

The turbine-electric propelling equipments included one for the *George W. Loft*, which is the third Staten Island–New York municipal ferryboat and the eighth ferryboat to be equipped with G-E electric propelling machinery. This craft is a sister ship to the *W. R. Hearst* and the *Rodman Wanamaker*, which entered service during 1923.

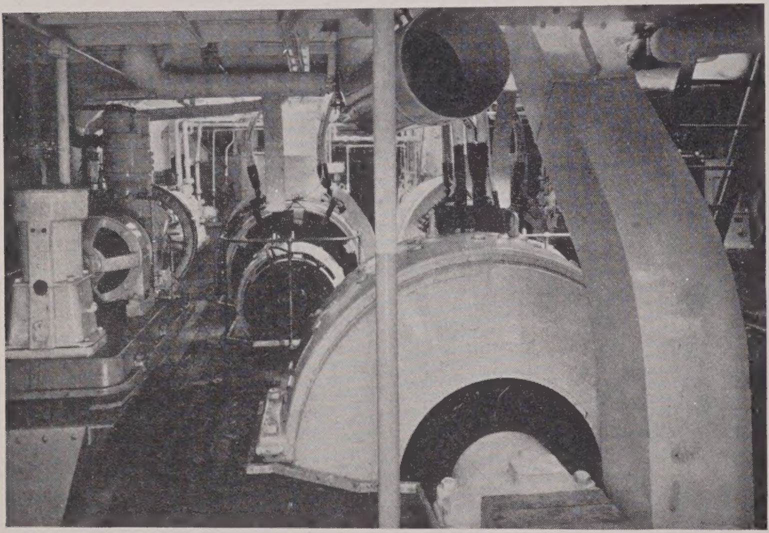

Fig. 7. View in Engine Room of Combined Tug and Fire Boat, Showing Engine-driven Generators and Propulsion Motor

Apparatus was also supplied for installation on the U. S. S. *Maumee*, an auxiliary oiler of the U. S. Navy, which was originally propelled by direct-connected Diesel engines.

For each of the airplane carriers, the U. S. S. *Saratoga* and U. S. S. *Lexington*, sixteen 22,750-h.p. motors and control apparatus were completed.

During December a contract was awarded for furnishing turbine-electric propulsion machinery, control apparatus, and electrical unloading equipment for the new 13,000-ton self-unloader type of vessel for the Bradley Transportation Company of Rogers City, Mich. It is expected that this ship will enter service in September, 1925, being the first on the Great Lakes to be propelled by turbine-electric drive.

Ship Auxiliaries

A unique type of mooring winch was designed which will automatically maintain a fairly constant tension on the mooring lines, thus obviating the necessity for the attendance of a man at each line to hold the ship in position during the loading or unloading of cargoes, or to compensate for the movement of the ship caused by wave motion or tides.

The control provides for operation either as an automatic tension machine or permits of manual operation for warping service with a predetermined limit of maximum rope pull. The control elements consist essentially of an automatic current-limit accelerating panel, a master switch, and a transfer switch mechanically interlocked, and a tension-limit switch actuated by a torsion spring gear in the power transmission system of the winch.

The master switch has a "dead-man" handle and is also arranged with an inter-

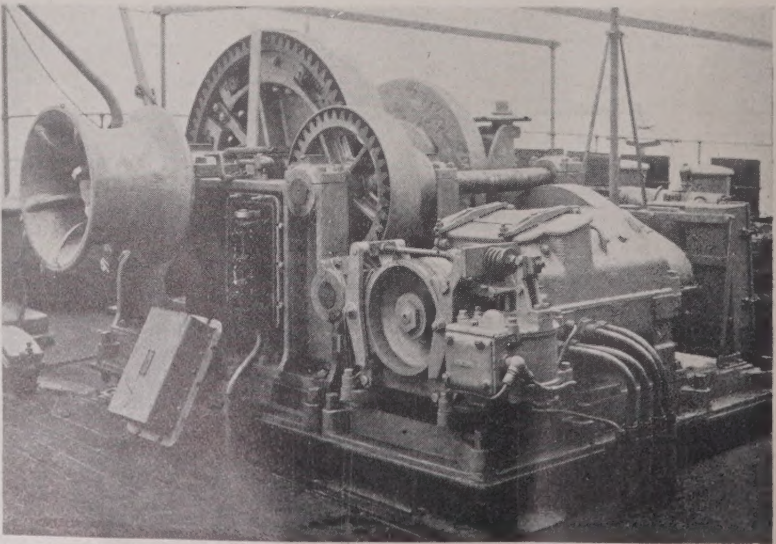

Fig. 8. Automatic Mooring Winch on M. S. *Cubore*

lock, locking it in the "off" position when the transfer switch is closed in the automatic position. Under this condition, when the pull on the cable on the winding drum is within the limit set for the equipment, all power is off the motor and the brake is set.

The control of the motor to "pay out" line, under the condition of excess rope pull and to "pull in" when the rope pull is less than the minimum limit, or slack, is accomplished through the agency of a spring gear which is a veritable torsion meter measuring the pull of the rope by a spring balance.

The spring gear is essentially a wheel whose hub and concentric toothed gear are not integral, but mechanically connected together by springs so that the driven member, whether hub or gear, may lag behind the driving member by an angle proportional to the torque being transmitted. The angle of lag is utilized to operate the tension-limit switch. It is apparent that with no rope pull on the drum the spring gear will have an angle of operation, and the tension switch will be in the position to give "pull in."

As a warping winch, with the transfer switch closed in the hand position, it is possible to obtain two speeds pulling in and paying out.

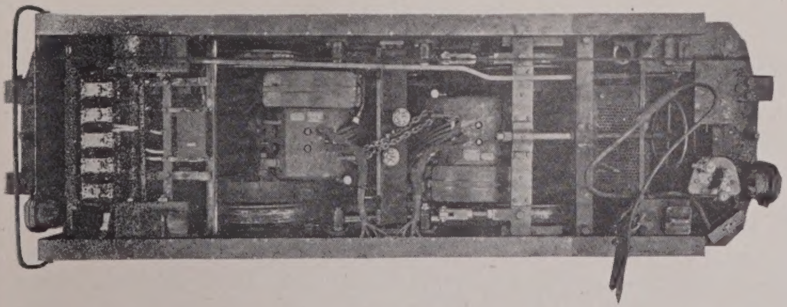

Fig. 9. Mine Locomotive Showing Arrangement of Contactor Control

Eight of these winches, each driven by a 50-h.p. motor, Fig. 8, were installed on the M. S. *Cubore*, a 10,500-ton ore carrier which entered service in February, 1924. In addition to these winches, all of the auxiliary machinery on this ship is electrically operated.

MINE AND INDUSTRIAL HAULAGE

The first haulage electrification of an open-pit iron mine in America was effected by the adoption of three 60-ton, double-truck, 500-volt mine locomotives by the M. A. Hanna Mining Company of Duluth, Minn. These locomotives are provided with auxiliary cable reels and current is supplied by means of an overhead trolley.

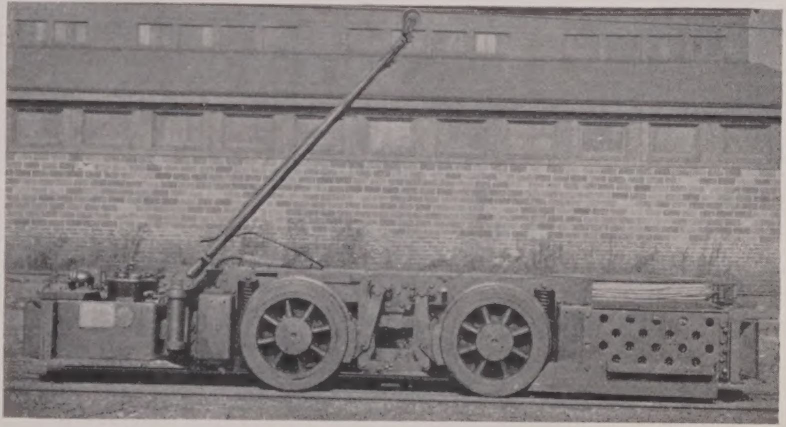

Fig. 10. Six-ton Standard Mine Locomotive Designed for Low Overall Height

Five 30-inch gauge, 25-ton 600-volt, direct-current locomotives built for the El Potosi Mining Company of Mexico are typical of modern mine haulage practice. They are arranged for multiple unit operation, regenerative braking, and forced ventilation of the motors.

As the result of long continued and exhaustive tests under actual service conditions, it was decided to adopt a standard arrangement of contactor control, Fig. 9, for mine haulage locomotives, so that either drum or contactor control could be provided as required on all sizes and in a standard arrangement.

Numerous locomotives with low overall height have in the past been built to meet special conditions in mining service. This led to the establishment of standard designs for low-height machines, Fig. 10, which will be suitable for a large majority of the cases which have heretofore involved special construction.

For a number of years past, there has been a steady increase in the capacity of storage.

battery locomotives, and during the year the largest one of its type so far constructed in the United States was placed in service. This unit, Fig. 11, is rated at 75 tons and the control is arranged for either battery or 250-volt trolley operation.

While the storage-battery locomotive as a commercial proposition is of comparatively recent origin, there is now available a complete line of these machines with ratings ranging from 4 to 75 tons; and so uniformly successful has this type been in recent installations that units rated in excess of 100 tons have been recommended for particular classes of service. These advances have been rendered possible not only by improvements in design, involving the mechanical and electrical equipment, but also by a corresponding development in the storage battery.

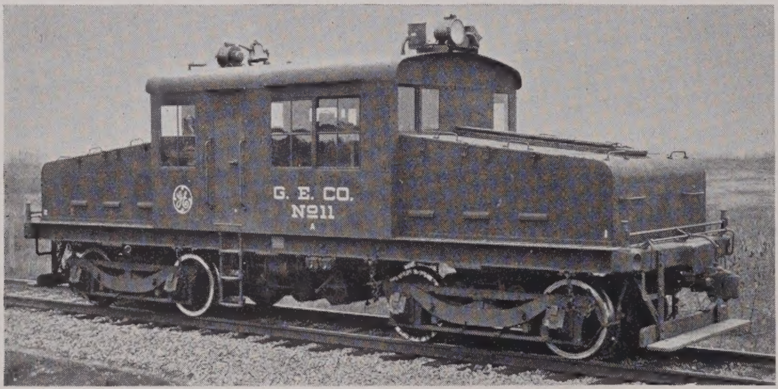

Fig. 11. A 75-ton Storage-battery Locomotive

ELECTRIC RAILWAYS

The sales of equipment for the operation of electric railways and electrified steam railroads have shown a steady improvement over the preceding year and inquiries now on hand indicate a continuance of the trend toward rehabilitation, including the purchase of modern equipment for both substations and rolling stock.

Self-propelled Locomotives and Cars

The 60-ton oil-electric locomotive, Fig. 12, which has been tried out extensively by a number of steam roads, has received much favorable comment. This locomotive is equipped with an oil-burning engine which was designed and built by the Ingersoll-Rand Company and which is direct connected to a direct-current generator. The generator, electric motors, control, etc., were supplied by the General Electric Company, while the cab and trucks were built by the American Locomotive Company. The unit is designed to replace a steam engine in switching service and the control is arranged so that it may be manipulated much in the same manner as that of the ordinary steam locomotive. The electrical equipment is arranged to operate automatically and the design is such that ample protection is provided against overload.(1)

Another similar development along this line which has received much attention is a gas-electric locomotive weighing 40 tons, built for the Pittsfield Works of the General Electric Company, Fig. 13. This unit is equipped with a Sterling-Dolphin gasoline engine direct connected to a 100-kw. electric generator. The control is similar to that on the oil-electric locomotive.

Interest has revived in the gas-electric car along the lines of the equipments built during the last ten years by the General Electric Company. This car is being developed by the Electromotive Engineering Company, using a 175-h.p. Winton gasoline engine, 110-kw. G-E generator, motors and control, and a car body and trucks built by the St. Louis Car Company. Two cars have already been furnished; one each to the Chicago and Northwestern Railway and the Northern Pacific Railway, Fig. 14. The car weighs complete about 35 tons and is capable of hauling one trailer, if necessary, making speeds up to 50 miles per hour. Comments from the officials of the railroad companies concerned indicate that this type of motive power will be very successful in branch-line passenger work.

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(1) General Electric Review, October, 1924, p. 673.

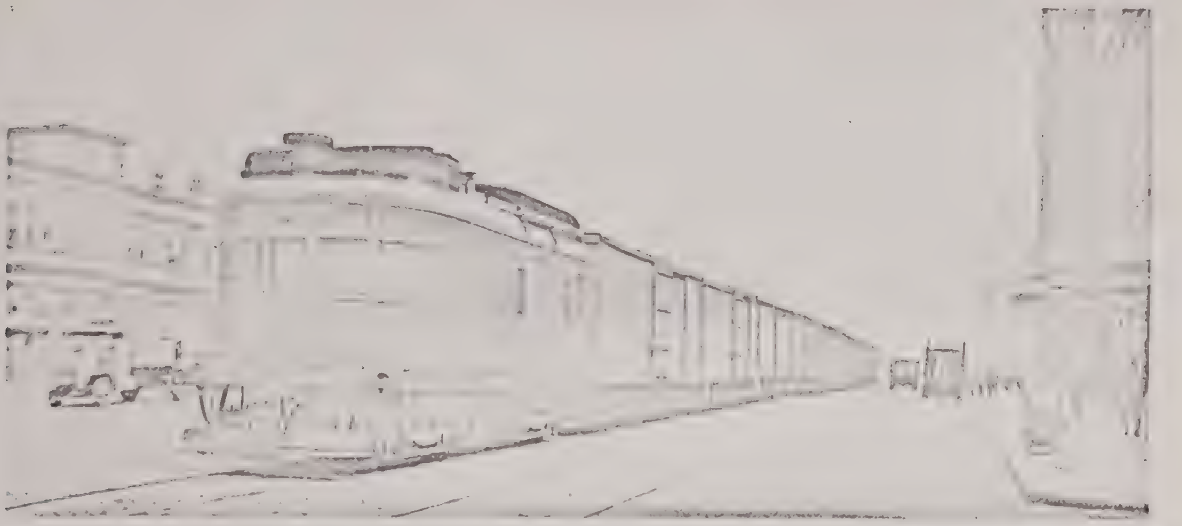

Fig. 12. A 60-ton Oil-electric Locomotive Handling Freight Cars on the New York Central Tracks

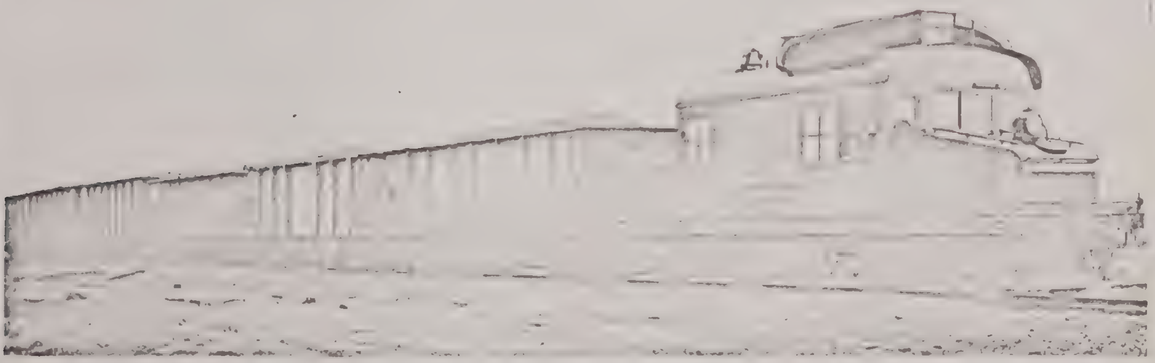

Fig. 13. A 40-ton Gasoline-electric Locomotive Handling Coal Train

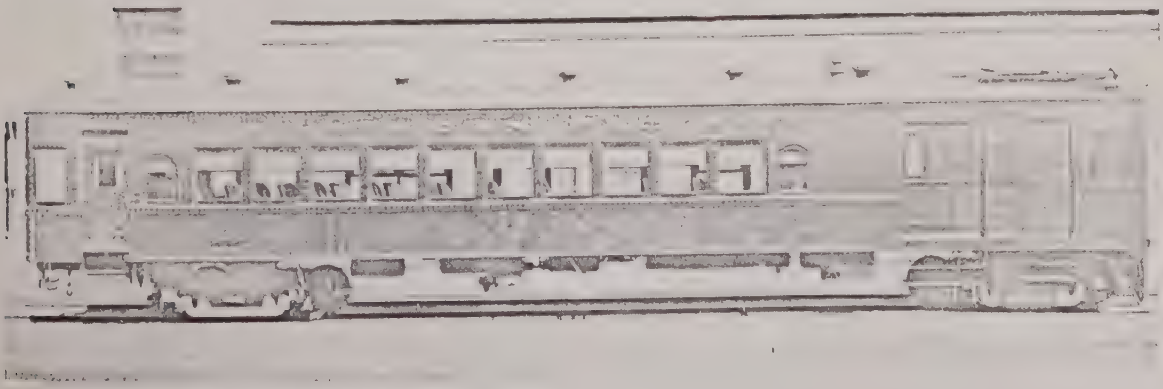

Fig. 14. A 35-ton Gasoline-electric Passenger Car

Steam Railroad Electrification

Renewed activity in railroad electrification was indicated by new equipment under construction for four different roads.

The most important of these projects is the Chicago Terminal Electrification of the Illinois Central Railroad, which decided over a year ago to electrify its suburban passenger service using 1500 volts direct current. The electric zone extends a distance of 28 miles from the terminal and comprises a total of 37 miles of route including two-, four-, and six-track sections.

The contracts awarded for multiple-unit cars and equipment include an order for 120 complete control equipments for the motor cars, 120 auxiliary control equipments for the trail cars, and motors for 60 cars. Each car will be equipped with four 250-h.p. direct-current motors operating two in series from the 1500-volt trolley. The motors will be geared for a maximum speed of 57 miles per hour at 1350 volts. The auxiliary equipment includes air compressors and governors, and separate lighting motor-generator sets to insure constant voltage for car lighting.

Each motor car will be permanently coupled while in service to a trail car and these two-car units will be operated in trains of two, four, six, eight, or ten cars from a single master controller.

Another important conversion is taking place on the Staten Island Railway, subsidiary of the Baltimore & Ohio Railroad, on the lines running from St. George, Staten Island, to Tottenville and South Beach. A total of 17 miles of route is involved, all double track. Equipment required includes 80 steel passenger cars to be equipped with two 200-h.p., 600-volt motors and type PC control. The traffic consists of a heavy passenger movement to residential sections originating largely from the municipal ferries. Connection is also made at Tottenville with the Baltimore & Ohio ferries to Perth Amboy, N. J.

New electrification equipment for the New York, New Haven & Hartford R. R. Company comprised five freight locomotives and two switching locomotives of unusual design. Each of the locomotives will carry a transformer and synchronous motor-generator set for stepping down the alternating current from the 11,000-volt trolley to direct current for operating the direct-current motors. These motors are of the usual standard design geared to the driving axles. It is expected that by this type of locomotive unit considerable advantage will be obtained by utilizing the superior power transmission at high voltage and the improved maintenance costs which are usual with the direct-current motor.

As part of its program for the electrification of the west side freight lines, the New York Central Railroad will utilize seven 100-ton switching and two 170-ton freight locomotives to handle freight traffic in New York city. These locomotives will be of the standard geared design using 600-volt motors.

A novel advertising trip was made during the summer by one of the 3000-volt direct-current gearless passenger locomotives of the C. M. & St. Paul Railway, beginning at Kalamazoo, Mich., and touring the entire eastern part of the United States. On account of limited clearances, it was not possible to visit the New England States. Exhibits were made as far south as Louisville, Ky., west as far as St. Louis, and a final exhibit of three days was made in Chicago. The interest aroused is indicated by the fact that more than 400,000 people passed through the locomotive for supervised inspection. Prominent visitors included Sir Henry Thornton of the Canadian National Railways, Thomas A. Edison, and many prominent railway officials.

Orders were placed during the year by the Japanese Imperial Government for four 66-ton, 1500-volt freight locomotives to be used in connection with the extension of present electric lines. These are similar in design to two units furnished in 1923.

The Mexican Railway Company, Ltd., began operation of its electric zone between Mexico City and Vera Cruz, and this electrification continues to hold the interest of railroad engineers throughout the country. Ten 150-ton, 3000-volt locomotives were delivered during the year and the substation was placed in operation shortly after the locomotives arrived.

Reports from Spain indicate very successful operation of the 3000-volt electrification of the Spanish Northern Railway over the Pajares gradient. The equipment now operating in this service includes six 90-ton freight locomotives and two complete 3000-kw. substations. Equipment was also furnished for the overhead line and the transmission system.

Another important development during the year was the construction of a 3000-volt motor car suitable for handling suburban service in heavy terminal work. This car is equipped with four 200-h.p. motors and type PC control, and is capable of handling a 40-ton trailer, Fig. 15.

City and Suburban Railways

The New York Subway and Elevated lines were the principal purchasers of equipment during the year for metropolitan rapid transit. The Interborough Rapid Transit Company, operating principally in Manhattan, purchased and had delivered early in the year 100 complete car equipments which consisted of two 195-h.p. motors and type PC control. In October an order was placed for 125 duplicate equipments and in addition motors and control for 25 cars using the 120-h.p. motor. The Brooklyn-Manhattan Transit Company also placed an order for two equipments consisting of four 200-h.p. motors, type PC control, and air brakes, to be used on the new type of articulated car. This unit will consist of three car bodies mounted on four trucks with motor equipment at each end. A separate controller will be used for each pair of motors with multiple-unit control.

In a number of the larger cities additional rolling stock was required for handling traffic on the surface lines. The Chicago Surface Lines ordered 100 car equipments which consist of two 60-h.p. motors with light-weight type M control, air brakes, and air compressors. The City of Detroit purchased 75 double-truck cars, each equipped with four 35-h.p. motors and type K control.

A novel application of motor equipment was made by the Interstate Public Service Company. It is customary to haul dining cars as trailers but in this case the car is self-propelled, the equipment consisting of four 140-h.p. motors and type PC control.

A number of roads are remodeling their equipment in order to obtain lighter weight rolling stock and a consequent reduction in operating costs. The Georgia Railway & Power Co. recently placed in service 20 equipments each consisting of four 35-h.p. motors and type K control. The New Orleans Public Service, Inc. ordered 30 equipments for light cars each equipped with two 65-h.p. motors.

Continued popularity of the center-gear type air compressor was indicated by large purchases, including among others 100 such compressors for the Public Service Railway Company, and for the Tokyo Municipal Tramways 100 air brake equipments including compressors.

Fig. 15. Motor Car and Trail Car with 3000-volt Equipment

Extensive rehabilitation was indicated by the purchase of supply equipment by the Los Angeles Railway Corporation, including 400 of the latest design type K controllers and 250 line breakers for use with type K control.

Gas-electric Buses

In taking care of surface line traffic, as feeders to its present trolley lines, the Philadelphia Rapid Transit Co. has been operating for several months a double-deck bus seating 64 passengers. This bus is equipped with gas-electric drive using a G-E generator, motors, and control. The experience so far has been so satisfactory that 200 additional units are now being constructed.

Automatic Railway Substations

Additions to automatic substation equipment were numerous for all classes of electric railways. The New York Central Railroad added a second 2000-kw. motor-generator unit to its 110th Street Station and is also installing a similar unit at Wakefield. A 2500-kw. converter, the largest machine of its type so far equipped with automatic control, is being installed at Scarsdale.

The largest single unit to be automatically controlled for railway service is to be installed in the Spring Street Station of the Georgia Railway & Power Company. This consists of a three-unit 3000-kw. motor-generator set having two 600-volt generators designed to supply power to both positive and negative voltage.

The largest single order for automatic railway equipment ever placed in this country was received from the city of Detroit, and consists of ten 2000-kw. synchronous converters, four 1000-kw. synchronous converters, with high-speed breaker protection to supply power to the city-owned lines in Detroit. All of these units will be installed in single unit stations.

Equipments under construction for the Illinois Power & Light Company consist of four 1000-kw. units with automatic control, and automatic control for three 500-kw. units which are now manually operated. There was also a two-unit station outfit to supply power to the Miami Beach Electric Company's lines in Florida, with two 750-kw. synchronous converters to operate in parallel.

Some of the other larger units under construction include the following:

San Francisco, Oakland Terminal Railways
  One 1500-kw. motor-generator set
Chicago, North Shore & Milwaukee Railway
  One 1500-kw. synchronous converter
Los Angeles Railway Corporation
  One 1500-kw. synchronous converter with six feeders equipped with high-speed circuit breakers and reclosing equipment. This unit is installed in a noiseless substation similar to several stations now in service.

In this connection it is of interest to note that in a large percentage of the equipments for automatic railway control, high-speed circuit breakers are utilized for protection.

AUTOMATIC STATIONS

The automatic station has become firmly established as an economic and operating necessity in the electrical industry. With its inherent advantages beyond dispute, a marked advance in the application of this type of control occurred, Fig. 16, in 1924.

There were no radical changes in the design of automatic switching equipments. The tendency during the year was to produce unit equipments which are easily handled and installed, and to standardize wherever possible. Standardization has progressed to such an extent that complete automatic stations for mining and industrial service are now being stocked.

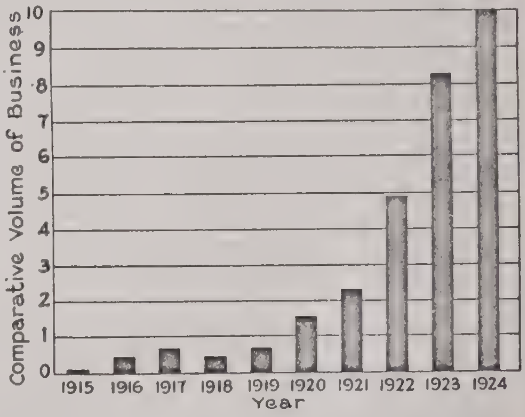

Fig. 16. Growth in the Volume of Automatic Station Business for the Past Ten Years

Automatically controlled hydro-electric generating equipments have made it possible to develop economically the small isolated water-power site as they have eliminated the necessity for attendants, thereby decreasing the operating cost. Many power companies are taking advantage of this fact and are installing small automatics, Fig. 17, to operate in conjunction with their large manually operated stations, while others are developing large power sites and installing large capacity multiple-unit automatic stations.

The largest installed single-unit automatic hydro-electric station in the world, Fig. 18, rated 7300 kv-a., 6000 volts, 60 cycles, is now successfully operating near Little Falls, N. Y., at the Sprite Creek Development of the Adirondack Power and Light Corporation.

The Wisconsin Valley Electric Company placed in service at its Alexander Dam Station three 1750-kv-a., 2300-volt, 3-phase, 60-cycle automatically controlled units, which are to be equipped with an automatic contact-making device to simulate the manual operation of regulating load by controlling the synchronous speed governor motor. Another installation of three 1250-kv-a., 2300-volt, 3-phase, 60-cycle units by the Tomahawk Kraft Paper Company of Tomahawk, Wisconsin, also utilizes the contact-making device.

Construction work for the Northern New York Utilities Company includes automatic switching equipment to control two 9375-kv-a., 6600-volt, 3-phase, 60-cycle units at its Soft Maple Falls Plant and two 12,500-kv-a., 2300-volt, 3-phase, 60-cycle units at its Sewell Island Plant.

The Holyoke Water Power Company of Holyoke, Massachusetts, is erecting an automatic station which will include one 625-kv-a. and two 1500-kv-a. units. These three machines will be remotely controlled over a distance of one mile. It will be possible to start and stop, raise or lower the load, and indicate gate opening on each machine at the remote station.

The growing popularity of automatic equipments for mining and industrial service was evidenced by a large number of installations; those in the coal fields, Fig. 19, being more numerous than in any preceding year.

To meet the requirements for this class of service, one type of standardized design is so arranged that a single-machine automatic-control equipment may be used in either a single or multiple-unit station with any number of reclosing feeders, thus giving maximum flexibility since it allows the arrangement of converting units in any desired manner with a possibility of later re-arrangement if called for by a change in load conditions. This may then be accomplished without modification of the control.

Fig. 17. Typical Small (492-kv-a.) Hydro-electric Station with Automatic Control, Continental Gas and Electric Co., Fullerton, Neb.

The line of automatic reclosing equipments for 275-volt mining and industrial service was extended and standardized so that all ratings are now mounted on a uniform size of panel. For use in partially automatic stations, the field rheostat and machine voltmeter are mounted on the panel with the automatic reclosing equipment. Such a station switchboard thus consists of only two panels.

Fig. 18. The Largest Automatically Controlled Waterwheel-driven Generator, 7300-kv-a., at the Sprite Creek Development of Adirondack Power and Light Corp.

During the year several installations of two-unit equipments were made and the problem of operating two over-compounded machines in parallel was satisfactorily solved by the use of a load balancing relay.

An automatic reclosing equipment, Fig. 20, suitable for inside mine sectionalizing service is enclosed in a steel weatherproof housing.

One of the most interesting installations for lighting service was made by the New York Edison Company at its East 41st Street Substation where two automatic control equipments, one consisting of two motor-generator sets and the other consisting of one motor-generator set, were installed with provision for one additional unit in the future. Two motors are to operate together as a unit while the 250-volt direct-current three-wire generators which they drive supply separate buses, feeding to different distribution points. When all units have been installed, there will be a total generating capacity of 6000 kw., and the driving motors will have a total rating of 8200 kv-a. at 11,000 volts, 25 cycles.

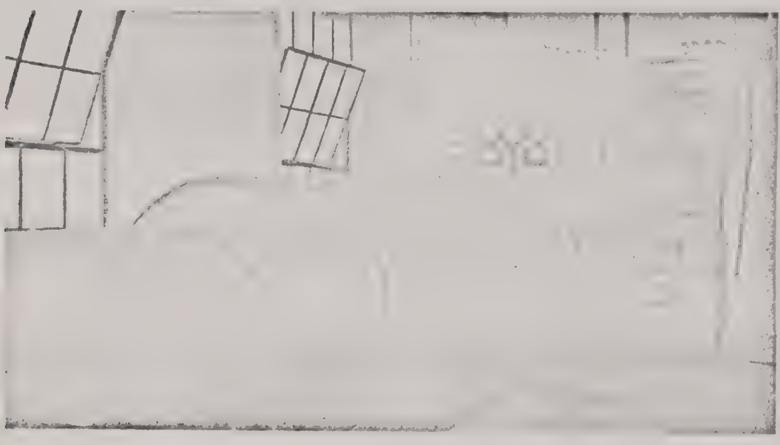

Fig. 19. 300-kw. Automatic Station for Mining Service, Heisley Coal Company, Nantyglo, Pa.

The motors are designed to start with their windings Y-connected, and when synchronous speed is reached the windings are automatically connected delta.

A distributor type of supervisory control is used to supervise these equipments from the 39th Street Substation. By means of this equipment, the machines may be started or stopped, load can be regulated at will, the generators may be disconnected from the buses, voltage indications may be obtained, and various other operations are also under the direction of the dispatcher at the 39th Street Station.

The Columbus Railway Light and Power Company installed equipment to control two 1800-kw. synchronous motor-generators in its Gay Street Substation. One 13,200-volt, 3-phase, 60-cycle motor drives each generator. These motors are designed for Y-delta starting and are equipped with reactors for re-synchronizing in case of necessity. The equipments will supply power to a 250-volt direct-current 3-wire system, and it will be possible to control the voltage either manually or automatically.

The Buffalo General Electric Company placed in service an automatic switching equipment for controlling one synchronous motor-generator set of 1875-kw. capacity, the motor operating on 11,000 volts at 25 cycles and being started by means of reactors. When synchronous speed is reached, it is automatically connected directly to the line.

Automatically controlled synchronous-condenser stations have proved particularly serviceable, as it is possible to place them in the exact location where power-factor correction is required without the added expense of supplying attendants. It is interesting to note that the New England Power Company installed at the American Steel and Wire Company's mill at Worcester, Massachusetts, a 7500-kv-a., 13,800-volt synchronous-condenser equipment which was the largest of this type.

A voltage regulator, Fig. 21, automatically controls the equipment to supply leading or lagging kilovolt-amperes to the transmission line, depending upon requirements. The

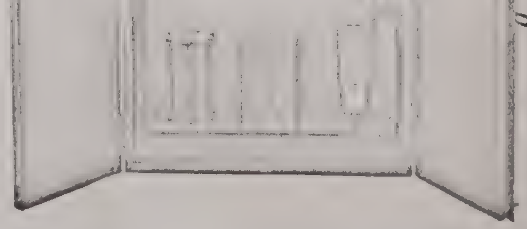

Fig. 20. A Self-contained Automatic Reclosing Equipment for Mine Sectionalizing Service

starting and running breakers receive their power for closing from the alternating-current bus and from the exciter, thus eliminating the storage battery for this purpose. In order to reduce the starting kilovolt-amperes of the machine to a minimum, oil under high pressure is automatically forced into the machine bearings before the starting sequence is begun.

Supervisory Control

The great increase in the number of automatic stations installed has created a demand for supervisory control systems, Fig. 22, by means of which the control and indication of widely scattered electrical apparatus of a power system can be concentrated under the observation and direction of a load dispatcher.

There are three classes of supervisory control systems, namely, the cable, the distributor, and the selector types. The cable type is used where the apparatus to be controlled is within a radius where multiconductor cable can be economically installed. The distributor type is best suited for power systems where a large number of operations per station are required and the stations are within a radius of 20 to 150 miles. The selector type is suitable for installations in which few operations are required per station and where the stations cover a wide area.

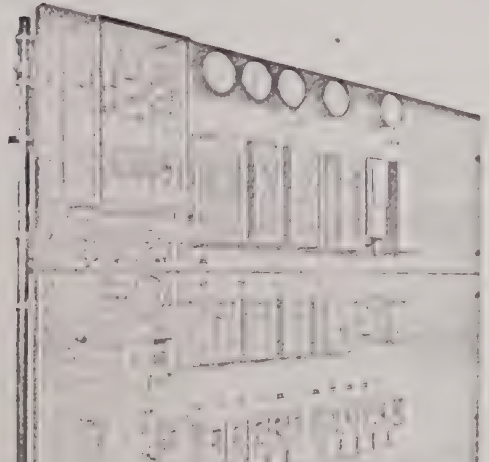

Fig. 21. Automatic Control Panels for 7500-kv-a., 13,000-volt Synchronous Condenser, Power Construction Co., Worcester, Mass.

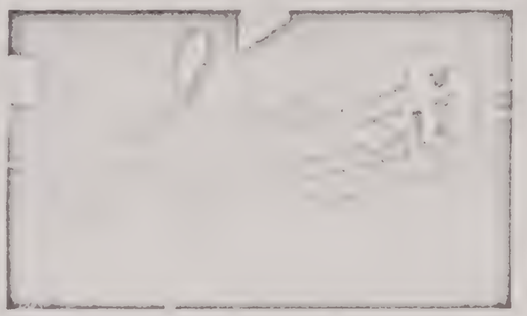

Fig. 22. Load Dispatcher Operating Remote Breakers by Means of Distributor Supervisory Control

The various manufacturers of automatic station equipment have in the past used their individual nomenclature in referring to the different operating devices, and this inevitably led to considerable confusion. Such conditions will very largely be avoided in the future as the Power Club has established rules whereby all automatic station devices are designated by numbers to identify their functions and these rules have been generally adopted by the manufacturers.

A description of the relays that have been developed for automatic station applications appears on page 46, under the heading "Relays," which also includes relays developed for other purposes.

WATERWHEEL GENERATORS

The installation of the second 65,000-kv-a., 12,000-volt, 25-cycle, 107-r.p.m. waterwheel generator for the Niagara Falls Power Company was completed about the middle of the year. The first unit has now been in successful operation for more than a year and the second one for more than six months. They still represent the maximum development in capacity, and physical dimensions for this type of machine, Fig. 23.

Among the large size generators under construction, there were four rated at 32,500 kv-a., 12,000 volts, 60 cycles, 100 r.p.m. for the Hydro-electric Station at Muscle Shoals. While the construction of these machines is along conventional lines, they are designed for very high efficiencies in

order to meet the requirements of the government engineers for the most effective use of the available water.

A 23,160-kv-a., 13,200-volt, 36-cycle, 154.4-r.p.m. generator was under construction for the Tallassee Power Company for installation at Baden, North Carolina. While this machine is designed for operation at 36 cycles to meet present requirements, the rotor spider was laid out and holes drilled in anticipation of future operation at 60 cycles; the present layout permitting the changeover to be made by changing the number of poles and reconnecting the armature coils.

Among other units of exceptional size, but standard characteristics, were four rated at 18,750 kv-a., 6600 volts, 60 cycles, 100 r.p.m. for the Southern Power Company, one of 14,060 kv-a., 6600 volts, 50 cycles, 375 r.p.m. for the Erbo Irrigation Project in Spain, two of 19,500 kv-a., 6600 volts, 60 cycles, 300 r.p.m. for the Baker River Development of the Puget Sound Power and Light Company of Seattle, Wash., and three of 11,110 kv-a., 11,000 volts, 25 cycles, 300 r.p.m. for the Salt River Valley Water Users' Association of Phoenix, Ariz.

FREQUENCY CONVERTERS

The interconnection of power systems has become of great importance in recent years, both from an engineering and economic standpoint. The use of frequency converters for such ties between systems of different frequency has resulted in important developments in this type of equipment.

During the past year a distinctly new type was developed, making practical the interconnection of systems where frequency variation between them is such as to prevent the successful use of frequency converters previously available. A new record was also made in the maximum size of frequency

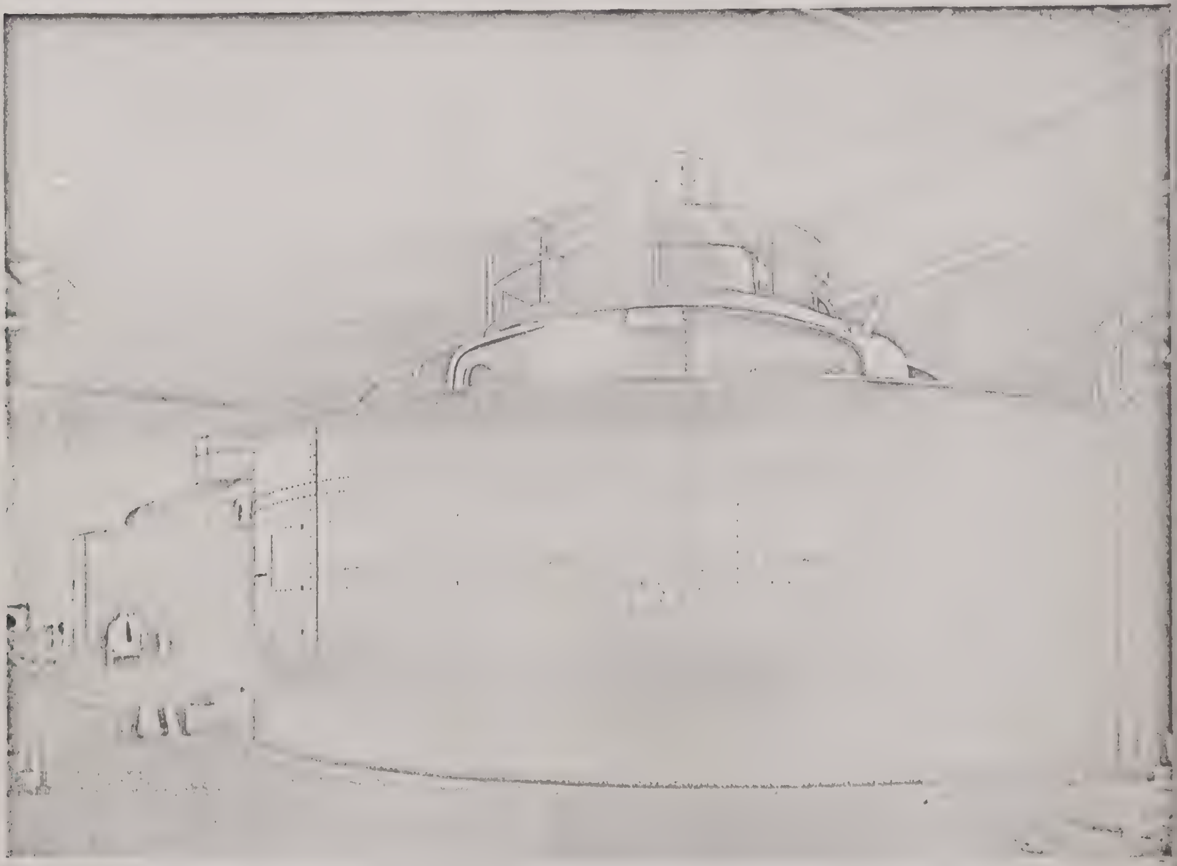

Fig. 23. 65,000-kv-a. Waterwheel-driven Generators, Niagara Falls Power Company

converters, as work was in progress on a 25- to 60-cycle set having a continuous capacity of 40,000 kw. from 25 to 60 cycles and 38,000 kw. in the reverse direction. The largest machines previously built were rated 35,000 kw.

When a rigid frequency tie is made (as in the case of a synchronous set) a fixed relation must be maintained between the speeds of the two systems so that if the frequency of one system changes from time to time, the other must make corresponding changes. Otherwise, the set will pull out of step. Load transfer must be regulated entirely by setting the governors on the prime movers of the two systems and the set can be synchronized only by adjusting the speed of the two systems.

During the year there was put on the market a type of frequency converter in which the foregoing operating limitations were overcome. This is known as the "Scherbius-controlled Load-regulating" type of set. It consists of a synchronous generator direct connected to an induction motor, with a Scherbius speed-regulating set. This regulating set makes it possible to hold any desired load with the ratio of frequencies of the two systems at any value within the range of the equipment. The speed-regulating type of set does not require a fixed relation between the two system frequencies. It can remain connected between systems and deliver load in proper amount and direction with variations in system frequencies within the limits for which the set is designed.

It can be arranged to hold constant load in either direction with speed variations of either or both systems by control of the set itself, that is, it does not require governor control of the prime movers of the two systems to regulate the load on the set.

Two sets of this type, Fig. 24, each rated 6000 kw., were installed by the Rochester Gas and Electric Corporation, forming a tie between the Rochester 60-cycle system and the Niagara, Lockport and Ontario 25-cycle system. These sets provide for a total variation of 9 per cent in the two system frequencies. Thus with the frequency of one system constant the other may vary 9 per cent above or below normal, and with both system frequencies varying the total variation can be 9 per cent. Each set consists of a 7500-kv-a., 11,000-volt, 3-phase, 60-cycle synchronous generator direct connected to an 8500-h.p., 11,000-volt, 3-phase, 25-cycle wound-rotor-type induction motor. Scherbius regulating equipment is provided for the latter, consisting of a separate 300-kv-a. regulating set, an ohmic-drop exciter direct connected to the main set, and two small rheostats and control transformers. If the 60-cycle system frequency is constant, the sets will operate at a constant speed of 720 r.p.m. Depending on the frequency of the 25-cycle system, the induction machine will operate at above or below synchronism. The Scherbius type control equipment for the latter machine controls the load transferred.

Fig. 24. 6000-kw., 25/60-cycle Frequency-changer Set, at the left-hand end of which is an ohmic-drop exciter that together with other auxiliary apparatus controls the exchange of power between the systems

In the annual review of developments in the electrical industry during 1923, a description

was given[2] of the 35,000-kw. induction-synchronous frequency converter built in 1923 for the Hell Gate Station of the United Electric Light and Power Company, New York City. This unit, Fig. 25, has now been in operation over a year and not only met its specifications but had a sufficient margin so that with slight modification of the 25-cycle machine it was possible to design a second set of increased capacity with the same dimensions. This set was under construction for the East River Station of the New York Edison Company and has a rating of 40,000-kw. output (unity power-factor) to the 60-cycle system and a rating of 38,000-kw. (unity power-factor) to the 25-cycle system.

Fig. 25. 35,000-kw. Frequency Converter at Hell Gate Station, New York City. Induction starting motor in foreground

The air-blast transformer for the new set will be rated 18,500 kv-a., which is a new record in size of air-blast transformers. This transformer is provided with tap-changing switches and reactors for changing the ratio while under load so as to control the flow of wattless current to or from the 60-cycle system. By the addition of these devices it is possible to obtain a large condenser capacity for power-factor correction through the main induction unit at reduced loads on the set. It was found that the condenser capacity of this type of frequency converter exceeded that which would be obtained from a unity power-factor synchronous machine of the same rating. This is an important factor since the 60-cycle New York system operates at less than unity power-factor.

The new 40,000-kw. set will be equipped with a phase-shifting device on the stator of the 25-cycle machine for use when paralleling it with the present Hell Gate set. Thus it will be possible to divide the load between the two sets in any desired proportion.

INDUSTRIAL MOTORS

A new line of single-phase, adjustable-speed brush-shifting motors, Fig. 26, was produced having a 2½:1 speed range with constant-torque load. They are arranged for interchangeable 110- and 220-volt service and for hand or remote control.

The line of single-phase repulsion-induction motors, utilizing a squirrel-cage rotor construction and eliminating the centrifugal switch, was extended to include the odd-frequency motors and the reversing type of motor. The reversing type is capable of reversal from full speed in one direction to full speed in the opposite direction, such as for hoist and crane service, but requires special control in the case of elevators.

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[2] General Electric Review, January, 1924, p. 21.

Single-phase motor development also included a line of varying-speed repulsion motors designed primarily for direct connection to low-speed exhaust fans. These motors are totally enclosed and have the series characteristics desirable for fan load.

A new line of synchronous motors for driving air and ammonia compressors employs a double-bar squirrel-cage winding which permits the designing engineers greater control of the current and torque during the starting period of the motor, and in addition permits the motor to be thrown on at full voltage with the assurance of minimum starting current and proper torques.

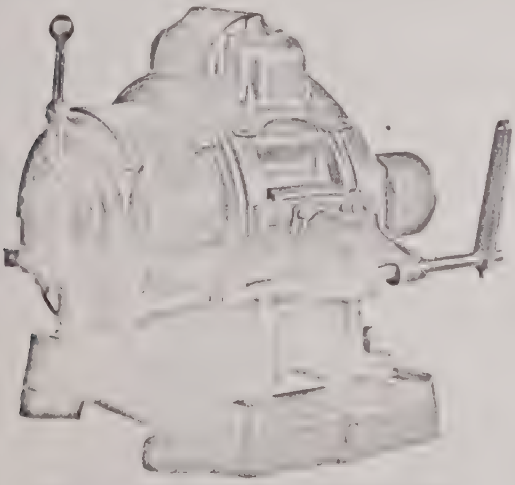

Fig. 26. Single-phase, Adjustable-speed, Brush-shifting Motor

A high-speed, drawn-shell type of motor was produced, intended primarily for the operation of woodworking machines although they are well adapted for grinder and similar service. They consist of stator and rotor only as they are intended to be "built in" on the driven machines.

Practically all sizes up to 35 h.p. are provided with two-pole windings, Fig. 27, and are suitable for operation on high frequencies. The speeds of course depend upon the frequency, and range from 3600 r.p.m. in the larger capacities to more than 25,000 r.p.m. in the fractional horse-power sizes. All sizes are arranged for double-end ventilation only.

The usual squirrel-cage motor is a low-reactance machine and has either a low- or a high-resistance rotor winding. A new line was designed with high reactance and either a low-resistance or a high-resistance rotor winding, Fig. 28, depending upon the application requirements. Such motors were applied quite extensively in the smaller sizes to refrigerating machines and in the larger sizes to driving pumps and other power-station auxiliaries. They are thrown directly on the line without any starter to reduce the voltage.

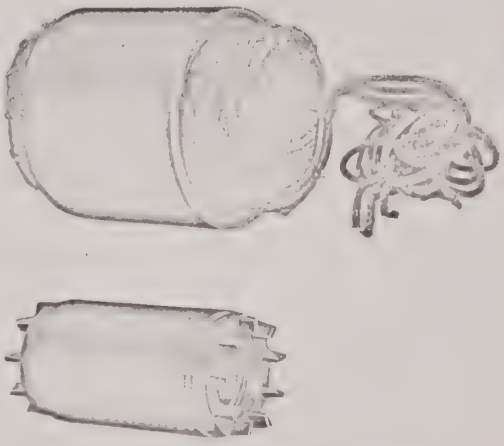

Fig. 27. Stator and Rotor of High-speed Induction Motor

Among the special motors was a group of 20 induction-type units designed for operation in an atmosphere containing one-half of one per cent of acetone. All of these motors are of the enclosed ventilated type, Fig. 29, taking in air from each end and discharging it through holes in the side of the

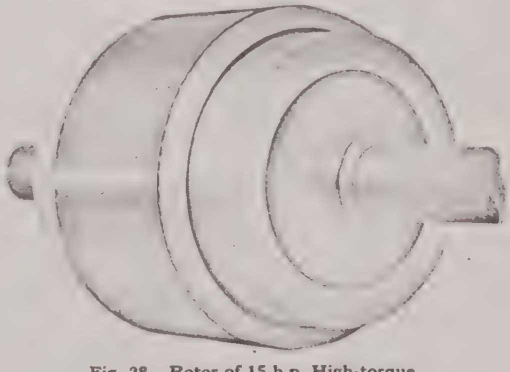

Fig. 28. Rotor of 15-h.p. High-torque Squirrel-cage Motor

stator frame near the bottom. The air will be supplied from an external source.

It is unsafe to operate the open motor, or even the ordinary enclosed type, in the presence of vapors from gasoline, ether, etc., and in order to meet better the requirements for operation under these conditions, a special construction was adopted, Fig. 30, for both motors and control apparatus. These motors were constructed only in ½- and 5-h.p. sizes, but the exhaustive tests which they passed with entire success indicate that the construction of industrial type motors can be modified so as to render them suitable for operation under gaseous atmospheric conditions.

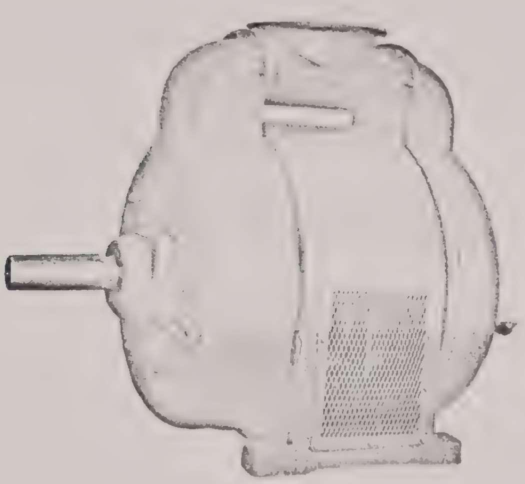

Fig. 29. Induction Motor Arranged for Special Ventilation

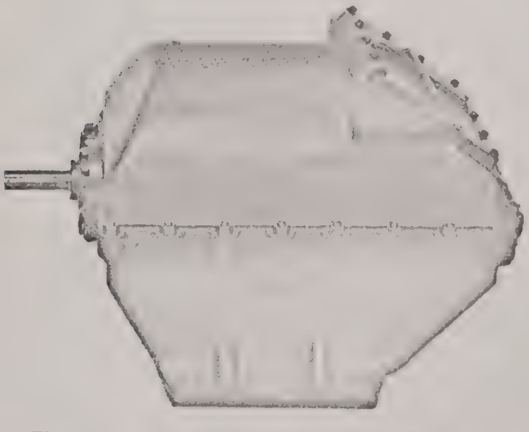

Fig. 30. 5-h.p., 550-volt Gasoline-fume-service Motor

INDUSTRIAL MOTOR CONTROL

For several years past it has become evident that the trend of safety regulations was toward the enclosure of all types of motor starters and speed controllers. During the year, work along this line was practically completed, and the remaining open-type starters and speed controllers were provided with either self-contained enclosing cases with external handle or were re-designed to accommodate enclosing cases where required.

Heretofore, fractional horse-power motors have, to a very large extent, utilized standard wiring device switches which were primarily designed for lighting circuits. A new design of single-pole and double-pole enclosed tumbler switches, assembled in boxes with conduit wiring, for throwing small motors on the line, now gives these motors a class of control equipment comparable with that provided for large motors. These new switches are given a definite horse-power rating.

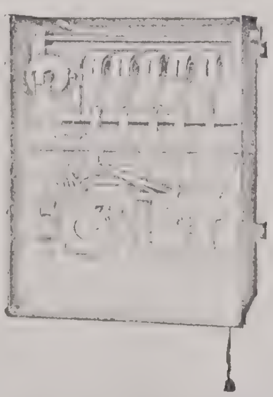

Fig. 31. Automatic Compensator with Time-element Acceleration and Thermal-overload Relay

An automatic compensator with time-element acceleration and thermal-overload relay was designed to replace the type utilizing current-limit acceleration and dash-pot retarded overload relays.

In this new compensator, standard alternating-current contactors are mounted back to back on a common base, Fig. 31, with a mechanical interlock between. This back-to-back arrangement makes possible a very compact switching mechanism with ample creepages between live parts of opposite polarity. The base is hinged, Fig. 32, so as to permit tilting it forward for the purpose of inspecting and getting at the contactor on its rear.

In addition to a thermal relay, which was utilized for the first time in an automatic compensator, there was provided a definite-time relay, Fig. 33, which is used to provide the accelerating period. It consists essentially of a motor-driven train of gears and magnetic clutch, and switching mechanism to provide for either opening or closing the contacts at the end of the time for which the device is set. It is adjustable from a few seconds up to several minutes, and is adaptable to many applications where a definite-time adjustment is needed.

A new thermal-overload relay, Fig. 34, was designed to follow the heating and cooling curve of the average induction motor, and is particularly adapted to service where it is important that the motor be permitted to carry heavy short-time overloads intermittently without being tripped out by the overload device. It will permit the motor to do any kind of work below a safe operating temperature.

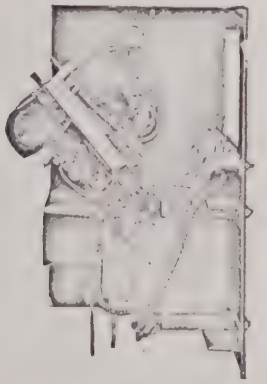

Fig. 32. Arrangement of Hinged Base on Automatic Compensator Shown in Fig. 31

Two forms of resistor-type magnetic starters for alternating-current motors were produced; one for squirrel-cage induction motors, and one for slip-ring motors. Mechanically these starters are very much alike, their difference being chiefly in the connections. They both employ a new type of time-element relay for the accelerating period that can be adjusted to about six seconds, which is ample time for the purpose. It consists essentially of an armature that is drawn across the face of an alternating-current magnet by a spring which is distended when the line contactor closes. The magnetism resulting from the alternating current intermittently attracts and releases the armature as it slides by the pole face, thus giving the desired time adjustment.

A motor-driven master timer for use with magnetic starting switches for controlling motors of reversing washers, as used in laundries, comprises a motor, gears, and switching mechanism mounted on one panel, Fig. 35, which can take care of two reversing equipments. Additional "trailers," which are switches to handle three reversing equipments, can be connected by means of a coupling to the first switch mechanism so that the same motor will drive, if necessary, a long train of reversing master switches.

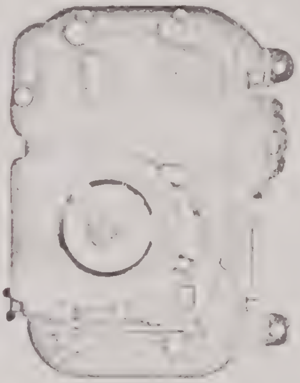

Fig. 33. Definite-time Relay for Automatic Compensator

For the control of two-speed oil-well motors, an oil-immersed switching mechanism was provided which utilizes magnetic switches for controlling the motors and master switches and operates by means of push rods for energizing the magnetic switches. By means of the push rod, Fig. 36, which extends through the top of the case, the motor can be started or stopped,

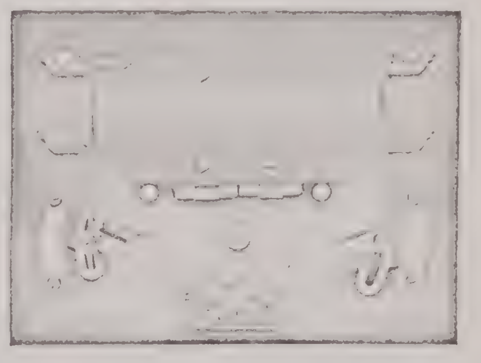

Fig. 34. Thermal-overload Relay for Motor Control

or thrown on high or low speed as desired. An additional rod is provided for resetting the overload relay, the contacts of which are oil immersed, the heater coils being above the oil.

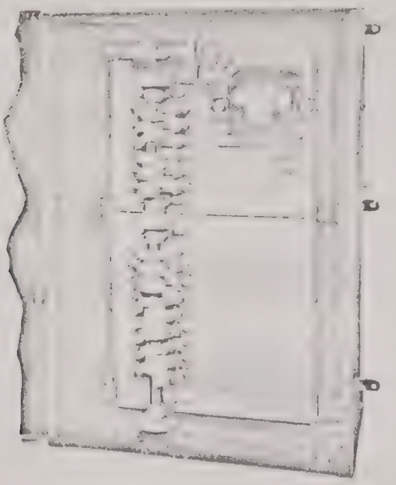

Fig. 35. Motor-driven Master Timing Switch

For the automatic control of motor-driven pumps, air compressors, etc., there was provided a new pressure governor for use in connection with automatic starters. Thi governor is of the Bourdon tube type, Fig 37, and can be used on any liquid or ga system that will not corrode the Bourdo tube. The equipment includes an "impulse' magnetically operated relay of a quic throw-over type that breaks its own operating circuit as soon as it functions.

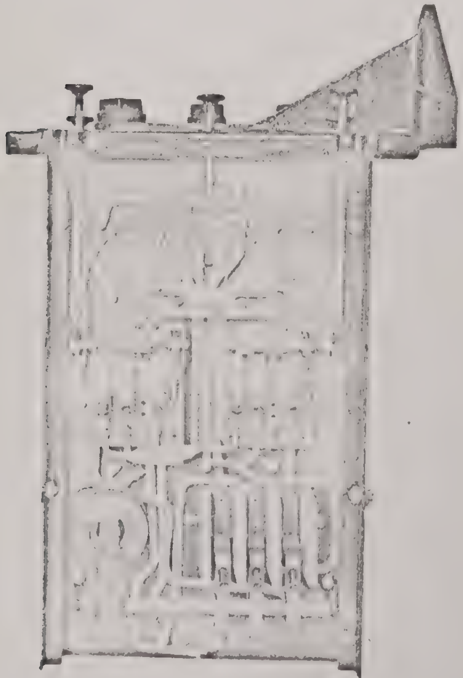

Fig. 36. Automatic Circuit Breaker and Pole Changing Switch for Oil-well Motors

A new design oil-immersed automati compensator, Fig. 38, was constructed t meet the particular requirements of grain-elevator operation.

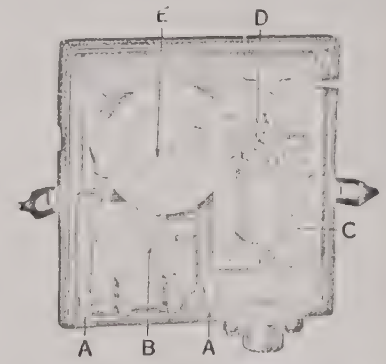

Fig. 37. Pressure Governor: *A*, Adjustable Contacts; *B*, Movable Contact; *C*, Relay Coil; *D*, Relay Contacts; *E*, Indicating Needle. The location of the adjustable contacts determines the pressure at which the motor is started and stopped

The compensator mechanism is enclosed in a tight cast-iron case and the switch is immersed in oil. The compensator is

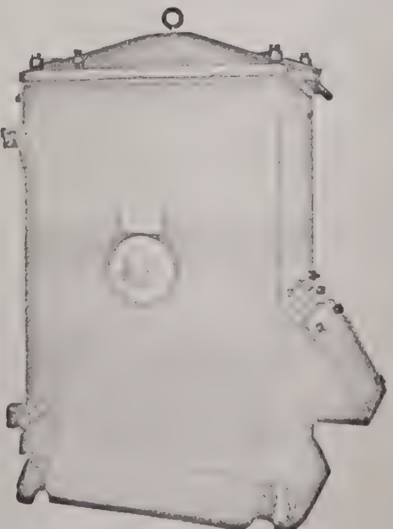

Fig. 38. Oil-immersed Automatic Compensator for Grain-elevator Operation

provided with a time relay for giving the accelerating period, and in the bottom of the case near the auto-transformer coils there is mounted a thermal-overload relay which has the unusual feature of electrical remote resetting.

MOTOR APPLICATIONS

There were many examples of the application of recently developed types of motors adopted in new fields.

The alternating-current brush-shifting adjustable-speed motor was utilized for the first time for the operation of stoker drives in boiler plants.

Another unusual equipment, Fig. 39, was designed for operating a newspaper press, the outfit including a separate starting motor geared to the main motor for starting the press and threading in the web. The speed of the main motor was varied through a range of approximately 3:1 by a pilot motor mechanism actuated by push button control for shifting the brushes of the main motor. In addition to securing remarkably smooth acceleration, and speed control, the operation of this equipment does not involve rheostatic losses.

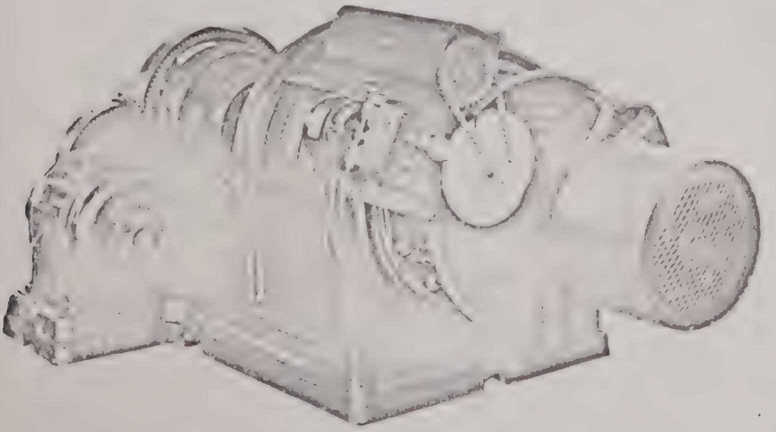

Fig. 39. Double-motor Printing-press Equipment

Another application of the brush-shifting motor was for the driving of textile finishing machinery, Fig. 40, where the operation of several motors in tandem may be required. In each case the speed of the main motor is controlled by push buttons through the operation of a pilot motor, which actuates the brush shift, while the speed of the other motor is controlled either mechanically or electrically by the motion of a compensating gate or floating roll between sections of the machine.

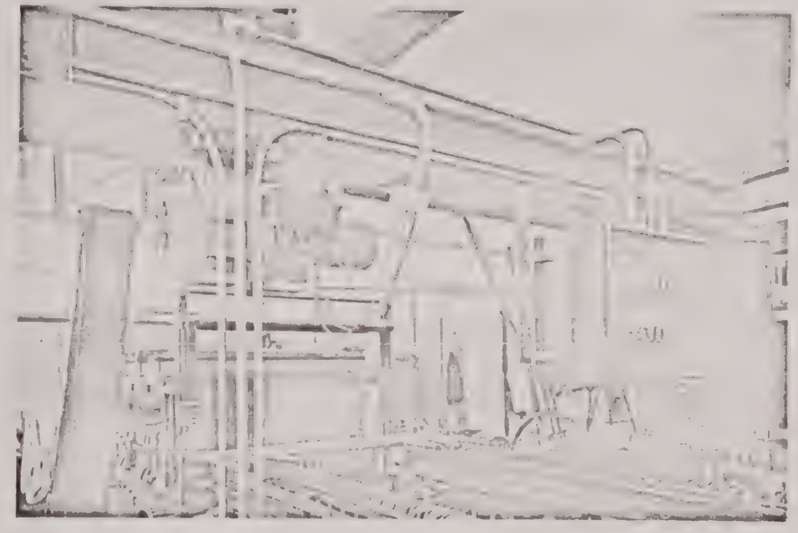

Fig. 40. Adjustable-speed, Alternating-current Motors Driving Mercerizing Ranges in Tandem. Main motor of one range with pilot motor for shifting brushes, and control panel

An alternating-current coal tower equipment comprising a 300-h.p. motor on the hoist and a 75-h.p. motor on the trolley was put into operation at Clairton, Pa., using straight time-limit control for acceleration instead of current-limit control as previously used. The necessary time element was secured by using a suitable number of direct-current contactors and allowing them to close in sequence, each one being interlocked through the preceding contactor.

This type of contactor was used to secure a slow time of closing, so that fewer contactor elements were required than would have been necessary with alternating-current contactors, and no time-element relays were used. This tower has

been in service for several months and has been entirely successful.

Small drawn-shell type motors of exceptional speed were provided for the operation of woodworking machinery. A typical application of this character consists of five small motors with operating speeds of 25,200 r.p.m., which are installed in a single woodworking machine, the current for these high-speed motors being supplied by means of a frequency changer. The motors operate on 3-phase, 240-volt, 420-cycle circuits.

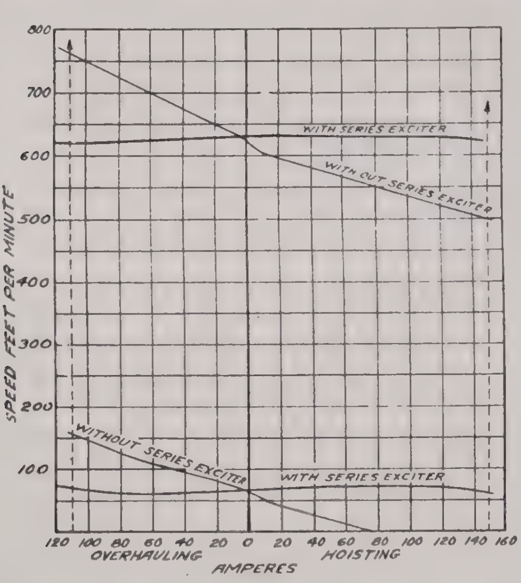

Fig. 41. Speed Regulation Curves of Elevator Motors

Induction motors designed to give a high starting torque with a relatively low current and a high efficiency when operating under load were applied for the first time to large systems of conveyors.

ELEVATORS

Radical improvements were made in the operating characteristics of high-speed elevators. One of the principal difficulties in the past has been that the speed, on any one speed position of the controller, is decidedly variable with the load, being slowest when the motor is hoisting the maximum load and fastest when the motor is being overhauled by the load.

This poor speed regulation has been detrimental in two ways: (1) if the speed under the worst overhauling load is adjusted to a value which is sufficiently safe and conservative, the speeds at balanced load and when hoisting the maximum load will be unnecessarily slow and will result in poor service; (2) it is difficult to land the elevator car at floors with sufficient accuracy, as the operator must manipulate the controller very differently and with good judgment at different loads in order to make proper landings.

The improved system consists, in brief, of a motor and motor-generator, controlled on the Ward Leonard principle but with the novel feature of an auxiliary series exciter by which a considerable degree of compounding can be successfully applied to the main generator to an extent entirely impracticable to apply in the ordinary manner. Fig. 41 shows the improvement of speed regulation effected by this system.

Although the system is new, it has already come into fairly extensive use. More than 50 equipments, divided among 12 installations, were in operation at the close of the year and 17 additional equipments were under construction.

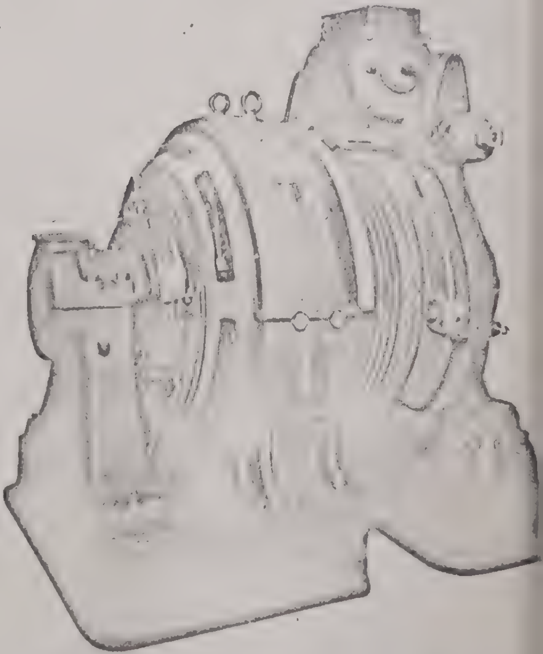

Fig. 42. Gearless-traction Elevator Motor with Rope Sheave and Solenoid Brake

The most impressive installation is a 393 Seventh Avenue, New York City, i the building recently completed for th Equitable Life Assurance Society. In thi building are 24 equipments of this typ Fig. 42, each for a live load of 3000 lb. a a speed of 600 ft. per min.

The motors are rated 35 h.p., 65 r.p.m., 230 volts, and at the first point of the control the car speed is approximately 1/15 of the full speed, thereby making accurate landing at the floors a very simple matter.

A practically constant coasting distance can readily be obtained when shutting off the car before making a landing, regardless of the load on the car and whether hoisting or lowering, by making a different adjustment of the series exciter. This result is accomplished without affecting the full-load speed which is maintained at full value when hoisting heavy loads so that there will be no time lost in handling the peak of the traffic.

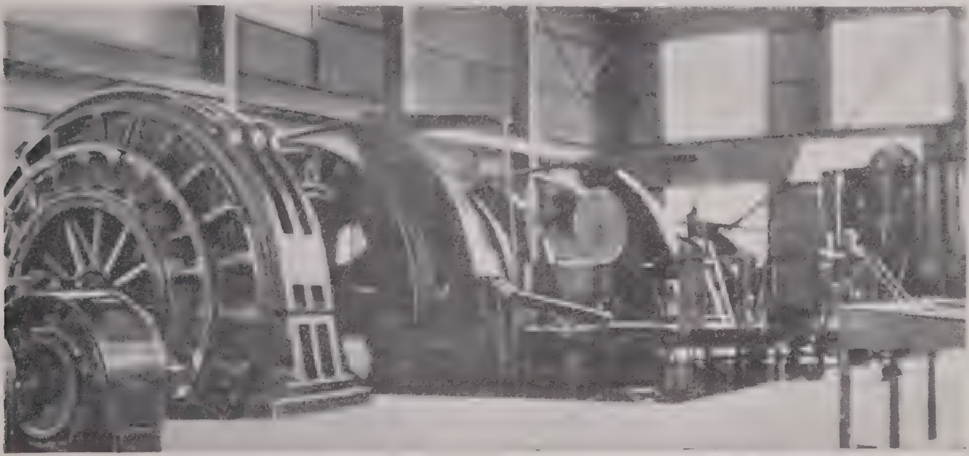

Fig. 43. Automatically Controlled, 2150-h.p., Direct-current Hoist Motor Direct Connected to the Hoist Drums

This system of control, using the series exciter, although originally developed for elevator service, appears to have possibilities for other applications requiring a very wide range of speed control and rather close speed regulation at the various speeds.

MINING

Two notable mine hoist equipments were put in operation at the Porphyry shaft of the Inspiration Consolidated Copper Company, Inspiration, Arizona, one being used for handling ore only, and the other for handling men and materials. These equipments are both of the Ilgner Ward Leonard type.

The ore hoist is of the automatic type, operating without a hoist engineer on the platform, and is arranged to hoist automatically from three different levels in the mine. The man and material hoist, while handled by a hoist engineer, is equipped with automatic features to insure maximum safety for handling men.

The ore hoist equipment consists of a direct-current hoist motor rated 2150 h.p., 51 r.p.m., 650 volts, direct connected to the hoist drums, Fig. 43, and a motor-generator set consisting of a 1600-kw., 500-r.p.m., 650-volt direct-current generator, a 1900-h.p., 500-r.p.m., 6600-volt, 3-phase, 25-cycle, slip-ring induction motor, and a steel plate flywheel 159 in. in diameter, weighing 78,000 lb. The hoist motor is the largest equipment of this type in physical dimensions so far constructed.

Excitation for the generator, hoist motor, and the control devices is supplied by a separate motor-driven exciter set. The control is similar to the ordinary hand-operated Ward Leonard hoist including a slip regulator and drum controller. The difference is that the controller is equipped with a pilot motor for turning it on and with cams geared to the hoist drums for turning it off. Provision is made for the accurate adjustment of the acceleration time, the speed during the retardation period, and the point at which the hoist is brought to rest.

An output of 10,000 tons of ore in 16 hours can be secured when hoisting from the deepest level (1485 ft.). Twelve tons of ore are hoisted per trip and a trip is completed every 69 sec. The skips are automatically loaded at the bottom and dumped at the top. The only attention required is a "loader" at the bottom who starts the hoist by closing a small master switch when the skip is filled with ore.

The man and material hoist consists of a 600-h.p., 400-r.p.m., 550-volt direct-current hoist motor which is geared to the hoist drum, and a motor-generator set consisting of a 450-kw., 750-r.p.m., 550-volt shunt-wound direct-current generator, a 500-h.p., 750-r.p.m., 6600-volt, 3-phase, 25-cycle, slip-ring induction motor, and a steel plate fly-wheel, weighing 16,500 lb.

The control for this equipment is the same as used on other hand-operated Ward Leonard equipments except that a master switch and contactors are used for controlling the generator field instead of a drum controller. This permits the use of current-limit control of both acceleration and retardation, which prevents the hoist from accelerating or retarding faster than certain predetermined rates so that even though the master switch is thrown immediately from the "off" to the "full on," or from the "full on" to the "off" position, the equipment will not be subjected to injurious strains or to excessive currents. It is also designed to limit the rope speed, when handling men, to 800 ft. per min. although the speed when handling material is 1550 ft. per min.

The five-mile electrically-driven belt conveyor system installed underground, which was referred to in the annual review for 1923, is used for transporting run of mine coal and is proving both efficient and economical. It has a capacity of 10,000 tons in 8 hours. The output is gradually increasing and it is hoped shortly to get the production up to capacity. During one day's run, it delivered 5792 tons of coal in 6½ hours, using 6858 kw-hr. of electric power or about 1.19 kw-hr. per ton delivered.

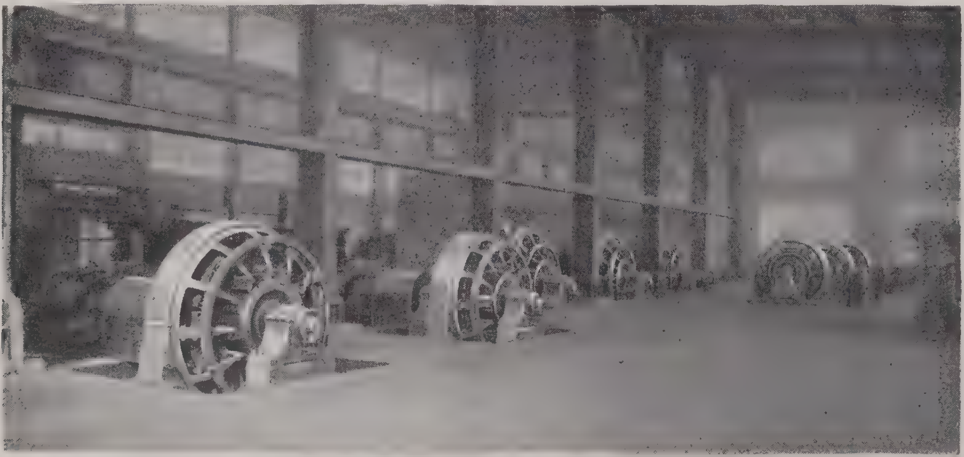

Fig. 44. Motor Room of 20-in. Hot-strip Mill, Otis Steel Company, Cleveland, Ohio, Showing Motors and Synchronous Converters

STEEL MILLS

By the addition of 47,150 h.p. (normal continuous rating) of main-roll motors during the year the total of G-E main-roll drives, Fig. 44, has been brought to over 662,000 h.p.

An installation of particular interest is a 14-in. continuous merchant mill at the plant of the Jones and Laughlin Steel Corporation. The nine stands of this mill are driven by seven adjustable-speed direct-current motors.

One 3000-h.p., 200/360 r.p.m.
One 1700 h.p., 90/140 r.p.m.
One 1700 h.p., 90/205 r.p.m.
One 2100 h.p., 150/310 r.p.m.
One 2100 h.p., 150/460 r.p.m.
One 2000 h.p., 210/680 r.p.m.
One 2000 h.p., 260/800 r.p.m.

This mill will roll a very large tonnage of diversified products and the employment of individual drives with a very wide speed range enables it to do the work of two or three less flexible mills.

The 26-in. rail mill at the Sparrows Point Plant of the Bethlehem Steel Company was changed over from steam to electric drive by the installation of two 3000-h.p., 500-r.p.m., 6600-volt constant-speed induction motors. This company also installed two 1250-h.p., 250-r.p.m., 6600-volt induction motors for driving hot tin mills, and another motor of the same rating for driving tin mill cold rolls.

The installation of the two revolving-frame or super-synchronous motors for driving copper rolling mills at the plant of the Rome Brass and Copper Company was completed; each motor being rated 580 kv-a., 0.7 power-factor (500 h.p.), 360 r.p.m., 440 volts, 60 cycles.

Two alternating-current brush-shifting adjustable-speed motors built for the Halcomb Steel Company of Syracuse, New York, for driving merchant mills, were placed in operation.

The Donner Steel Company of Buffalo, New York, will replace the engine drive on its 34-in. reversing blooming mill by a 4000-h.p., 58/120-r.p.m., 750-volt direct-current reversing motor. Power for this motor will be derived from a flywheel motor-generator consisting of two 1800-kw., 500-r.p.m., 750-volt, direct-current generators, a 78,000-lb. steel plate flywheel, and one 3000-h.p., 2200-volt induction motor.

ELECTRIC WELDING

A new type of direct-current arc-welding generator was developed in which the adjustment of the welding current is obtained by shifting the brushes. This machine, Fig. 45, is rated 250 amp., one hour, 50 deg. C. and 200 amp. continuous, and is capable of handling a maximum welding current of 300 amp.

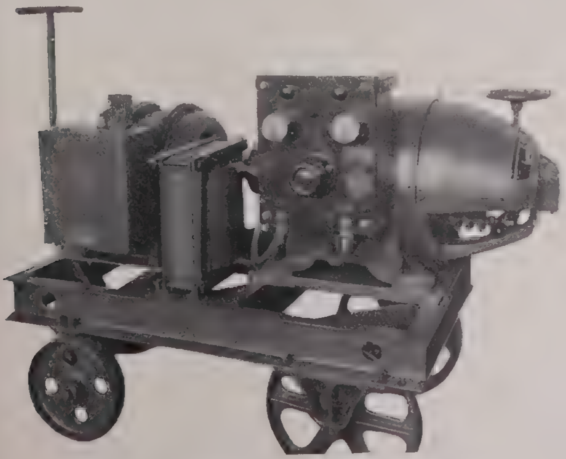

Fig. 45. Arc-welding Outfit with Brush-shifting Control of the Welding Current

The use of automatic arc welders showed a consistent increase, and new types of machines were produced for use in manufacturing.

As an indication of the results which were obtained with automatic welding machines, one manufacturer utilized them for the construction of 550-gal. underground gasoline storage tanks, Fig. 46, made of galvanized iron, each tank having three longitudinal seams 116 in. long, the material being No. 12 gauge ($\frac{7}{64}$ in.) stock.

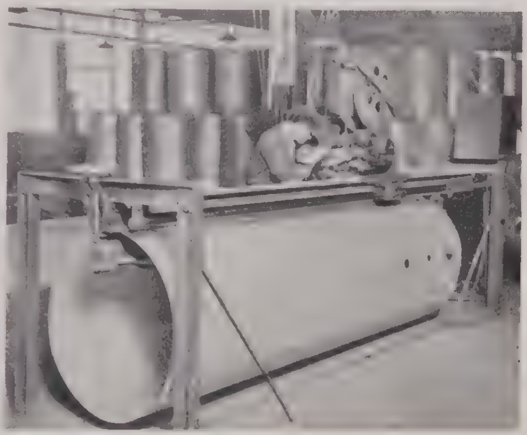

Fig. 46. Automatic Arc Seam-welding Machine at Work on Galvanized-iron, Underground, Gasoline Storage Tanks

In regular production, these seams were welded at an average rate of about 16½ in. per min. or a total of 7 min. per seam. The welding current was 200 amp. with about an 18-volt arc. Previous methods of manufacturing these tanks took about 7½ hours per tank, whereas the automatic welding machine reduced this to 5 hours. It is evident from this record that the arc welding of galvanized iron is entirely feasible, provided suitable welding electrodes are used.

INDUSTRIAL HEATING

The continued growth in the use of electric energy for industrial heating purposes was evidenced by an average increase of about 15 per cent in the amount of equipment of all classes produced.

The volume of miscellaneous forms of heating units for application to process machinery was about the same as for 1923, while equipment for industrial ovens for baking japan, foundry cores, etc., was somewhat less. The most marked increase was in connection with electric furnaces for heat treating and vitreous enameling; the production of this type of furnace showing an increase of approximately 70 per cent over the previous demand.

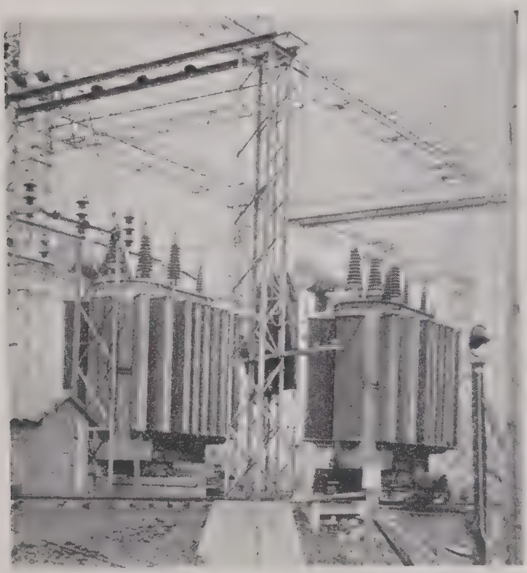

Fig. 47. Two 15,000-kv-a. Self-cooled Transformers, the Largest of Their Type

TRANSFORMERS

Early in the year the two largest three-phase, self-cooled transformers ever constructed, Fig. 47, were completed, shipped, and installed. They are rated 15,000 kv-a., 60 cycles, 72,000–132,000 volts with a 12,470-volt tertiary winding.

The efficiency of these transformers is in excess of 99 per cent from half load to full load and the regulation is 1.1 per cent.

Among the large self-cooled units under construction were four rated 15,000 kv-a., 60 cycles, 3-phase, 73,000–13,200 volts.

These units are indicative of the rapid growth in capacity which has characterized self-cooled transformer construction, Fig. 48, since 1920 when a maximum rating of 10,000 kv-a. was first attained.

The larger water-cooled units included two 20,000-kv-a., 25-cycle, 3-phase, 22,250–11,500-volt and four 20,000-kv-a., 60-cycle, 3-phase, 69,000–13,800-volt transformers, all provided with an improved type of tap changing equipment for switching under load.

The new ratio adjuster which was designed for this service utilizes standard contact fingers, Fig. 49, in place of the contact rollers previously used, but retains the simple and compact drum construction which is applicable for transformers of any type, size, or voltage.

In air-blast transformers, the maximum in capacity was increased by the construction of an 18,500-kv-a., 25-cycle, 3-phase, 11,800–2950-volt unit arranged for switching under load by means of reactors and switches.

Many detailed improvements were made affecting both the construction and operation of transformers of various types.

One of these consists of a scheme for bringing underground cables into the transformer without any exposed terminals or live parts, as shown in Fig. 50. The underground cable is brought up into a compartment filled with fluid insulating compound. Suitable links and connectors are provided in this compartment so that the cable may be properly "phased in." This compartment is connected by means of bushings to an upper compartment which is kept filled with oil by means of a pipe leading to the main tank. The transformer high-voltage bushings pass into this compartment through the side of the tank and links are provided so that the transformer may be disconnected to facilitate testing of the cable. Access to both compartments is attained by the removal of gasketed covers.

A year ago reference was made to the increasing demand for a means of changing transformer voltage under load and a full description was given of ten large transformers built for the Commonwealth Edison Co., which were designed for this purpose.

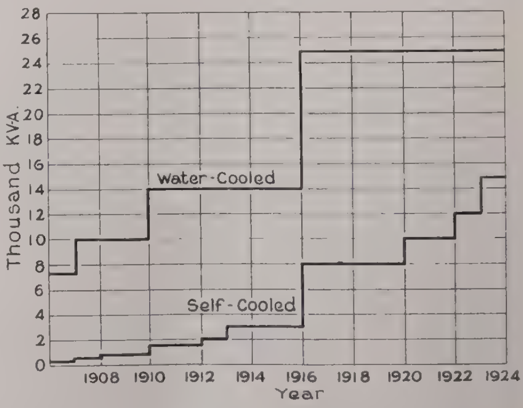

Fig. 48. Growth in Unit Capacity of Self-cooled and Water-cooled Transformers

Since that time there has been marked improvement in the methods adopted for accomplishing this result—notably, the development of a self-contained device. for performing the proper sequence of operation of the ratio adjusters and oil switches. The mechanism may be operated by hand or by motor, with remote control.

As originally applied, the scheme of changing taps under load made use of what is known as the multiple-circuit secondary. The cycle of operation is as follows:

> One of the parallel secondary circuits is opened by means of an oil switch, the position of its ratio adjuster changed one point and the winding again connected in circuit. The other parallel circuit is then opened, its ratio adjuster brought to a corresponding position and the circuit closed. This cycle is repeated until both circuits are on the desired tap.

One circuit must carry the entire current during the time the other circuit is open and a circulating current will flow while the two adjusters are not on the same tap. The circulating current is limited by the inherent reactance of the transformer.

This principle may also be applied to the so-called "single-circuit" secondary in which the multiple circuits necessary for the non-interruption of service during tap changing are limited to a very small portion of the winding. Here external reactance is used to limit the circulating current.

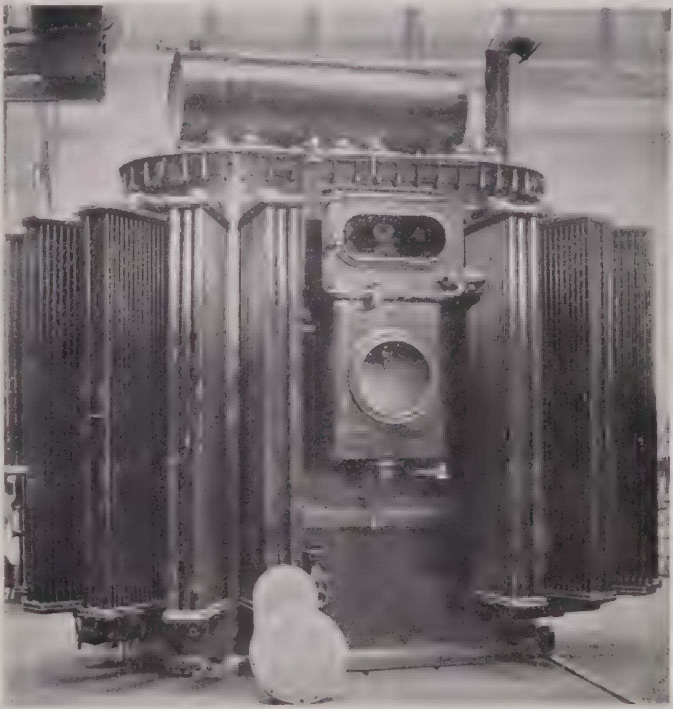

Fig. 50. Compartments for Bringing Cables Into Transformers Without Exposing Terminals

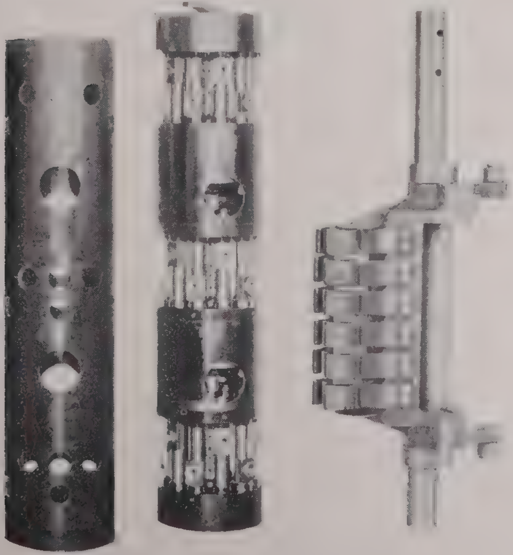

Fig. 49. Ten-point, Carb-type Ratio Adjuster; Center Illustration Shows Three-phase Assembly

The third arrangement consists of a special regulating transformer in series with the main unit. This arrangement is particularly adapted to single-phase units and also to situations where it may be desirable to keep the power units free of taps.

Important installations to which this scheme was applied during the year are:

Four units rated 60–20000–69000–13800 for the Philadelphia Electric Co.
Two units rated 25–20000–22500–11500 for the Buffalo General Electric Co.
A bank of three units rated 60–10000–14000–12500 for the Illinois Electric Power Co.

In this latter installation a special regulating transformer having a capacity of 3000 kv-a. was utilized for making tap adjustments.

A new type of load indicator for pole-type distribution transformers, with scale showing underload as well as overload, utilizes two thermometers; one, a tube of liquid immersed in the transformer oil, and the other a bi-metallic strip in the indicator case. These two thermometers are affected by the oil and the ambient temperatures respectively. They are so connected in series that the movement of the pointer which is caused by the oil thermometer is modified by the ambient temperature, Fig. 51, with the result that the pointer closely indicates the true winding temperature and the scale is conveniently calibrated directly in terms of safe continuous output. When safe temperatures are exceeded due to an overload, a conspicuous target which is normally concealed swings into view. This is in addition to the indication of maximum load given by the indicating hand.

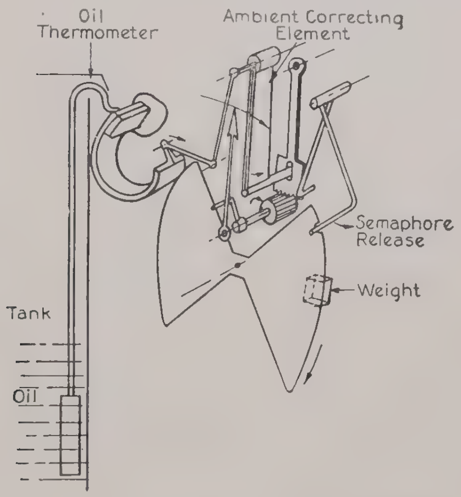

Fig. 51. Sketch of New Type of Load Indicator for Pole-type Distribution Transformers

The recent tendency to concentrate the transformation of electric energy in units of greater capacity was indicated by an increase, as compared with 1923, in the average rating of all types of transformers. Table I shows the average ratings for the past six years.

TABLE I

AVERAGE UNIT SIZE OF POWER TRANSFORMERS IN KILOVOLT-AMPERES

Year	Self-cooled	Water-cooled	All Types
1919	1175	4325	2150
1920	1325	3175	2175
1921	1575	4150	2750
1922	1700	6000	3750
1923	2350	5125	3220
1924	2475	5800	3650

At the close of the year there had been completed or were under construction a total of more than 230 units of 10,000 kv-a. or above.

HIGH-VOLTAGE BUSHINGS

Reliable high-voltage bushings are vital to the successful operation of modern power systems and it is therefore interesting to note that more than 30,000 of these bushings, ranging in operating voltage from 7500 to 220,000 and in current from 100 to 300 amp., were produced during the year. They were applied on power, potential, and current transformers, and on oil circuit breakers, while a small percentage were used for roof and wall entrance service.

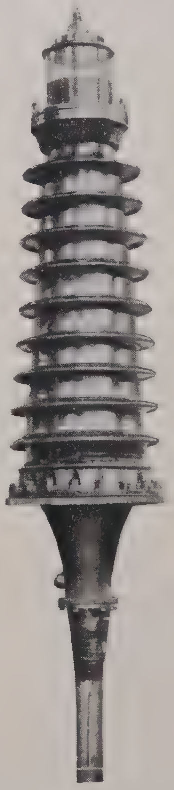

Fig. 52. Oil-filled, Porcelain, Cable Terminal for 110,000-volt Single-conductor Cable

Oil-filled bushings have been standard for a number of years for operating voltages above 73,000 and their practically perfect record of performance led to the adoption of a bushing of this type for voltages between 50,000 and 73,000. In general design the bushing is similar to the larger ones, and is so proportioned as to be interchangeable with the solid type of bushings for oil circuit breakers.

A recent development is that of oil-filled terminals for high-voltage underground cables, and for this service a line of porcelain terminals for single-conductor cables, Fig. 52, was produced and practically standardized. They have already been extensively tested in the laboratory and in the field, and have given every indication of reliability in service.

CONDUCTOR CABLE

The continual increase in the volume of electric power which must be transmitted in congested districts has served to emphasize the importance of development work on paper-insulated, oil-filled underground cables for higher voltages.

An extensive program of development was actively pursued in the laboratories and factory. In order to supplement this work by subjecting the cable to the voltage fluctuations which occur in actual operation, a field test was conducted with the co-operation of the Adirondack Power and Light Corporation on its 110,000-volt circuit at Albany, N.Y. A commercial length of experimental single conductor cable was put under continuous test on this line early in October.

The development of this cable has been paralleled by that of suitable cable joints and terminals for voltages up to 132,000. Fig. 53 shows this cable installed with its 110,000-volt cable terminals, together with an automatic oil circuit breaker for line protection in case of breakdown.

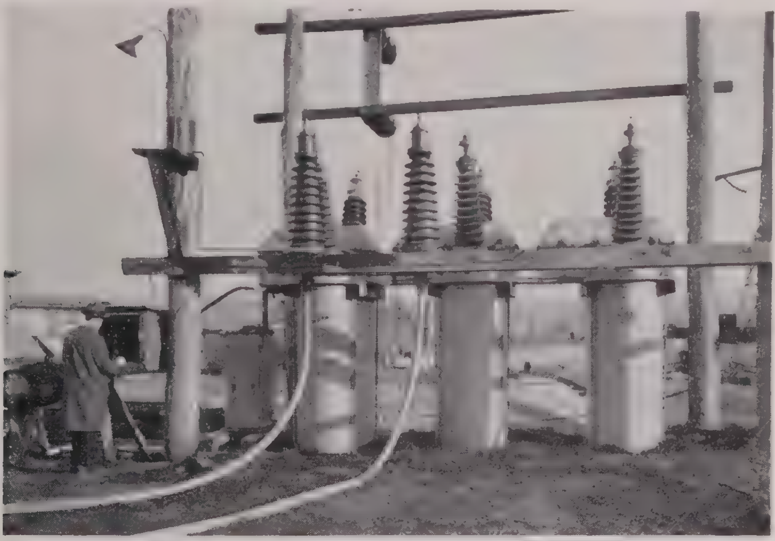

Fig. 53. Field Test of Single-conductor, Paper-insulated Cable on a 110,000-volt Circuit

CABLE TESTING SETS

The natural trend toward longer and higher-voltage cable systems resulted in increased interest in kenotron testing sets, and there was also a more general recognition of the importance of systematic testing to maintain operating systems at their highest service efficiency. Kenotron outfits permit such testing without appreciable operating expense, as no special generating equipment is required, and there is less danger to the cables because of the small amounts of power involved, as well as the practical absence of heating due to dielectric loss in the insulation.

The determination of the best method of fault reduction, after a cable has been broken down, is being carried on jointly by the manufacturer and the operating companies using this method. In order to supply a larger current for use in fault reduction, a new 200,000-volt outfit was designed in which four tubes are connected in series on the 200,000-volt connection, but they may be connected in series parallel or all in parallel to give one-half and one ampere respectively at reduced voltages.

To permit the required flexibility in the tube connections, a new method of assembling the rectifier units, Fig. 54, was adopted whereby the kenotron, protective gap, and balancing condenser are all mounted as a unit and supported by the high-voltage bushings of the filament transformers. A high-voltage switching rack is also provided.

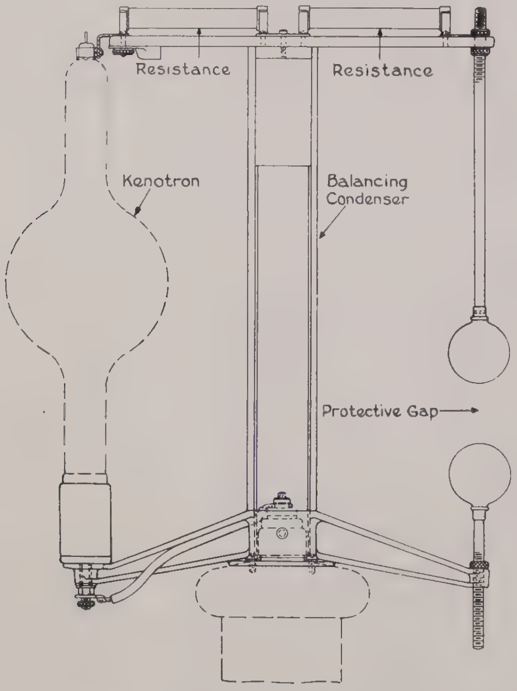

Fig. 54. Assembly of Rectifier Unit of Direct-current Cable Testing Set

In addition to the production of kenotron sets for cable testing, a high-voltage direct-current equipment was developed for producing voltages up to 500,000, or higher as required, by the assembly of 100,000-volt units, Fig. 55, connected in series. The condenser is first charged up from one end to the center on a positive half wave and in the same manner from the center to the opposite end on a negative half wave. Thus, the total charge of the condenser in terms of direct-current voltage equals double the r.m.s. value on the transformer times the square root of 2.

It has been found possible to design the sets in 100,000-volt units and then connect the required number in series for higher voltages, utilizing the so-called chain-connected method for the main transformer. Thus, while the complete unit must be insulated for the total voltage to earth, the transformer and condenser have only nominal insulation. With a set of this type, direct-current voltages of over 400,000 volts have already been obtained, which is believed to be a record. The equipments are suitable for laboratory and research work, and their use is limited to applications where only small power is required.

SUBWAY PRIMARY CUTOUT

A new fusible primary cutout for subway service makes possible the economical protection of transformers and other apparatus on high-voltage underground distribution systems. The cutout is single-pole and is normally rated 200 amp. at 15,000 volts with a guaranteed interrupting capacity of 5000 amp. or 75,000 kv-a. single-phase.

The principle of operation of this cutout is new. The fusible element is contained in an explosion-chamber fuse holder which is oil immersed in a heavy steel tank, Fig. 56, designed to withstand the pressures resulting from short circuit. The operating characteristic is very similar to that of explosion chambers used on high-capacity oil circuit

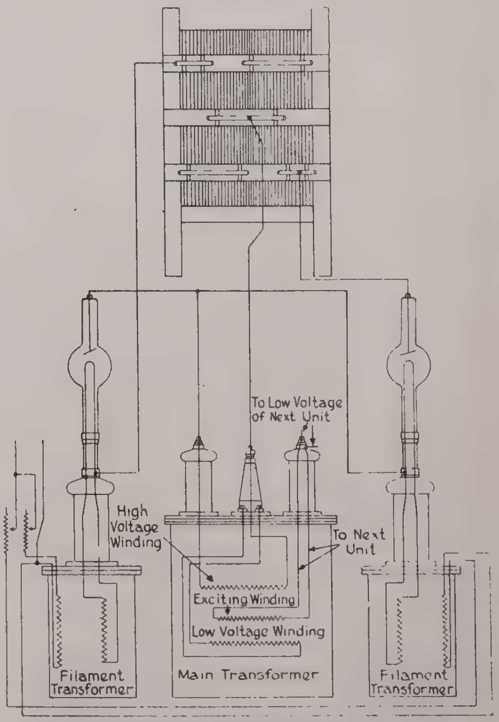

Fig. 55. Diagram of a 100,000-volt Unit for Direct-current Cable Testing

breakers. The cutout incorporates a very desirable safety-first feature in that the circuit can be opened and closed without opening the tank.

LIGHTNING GENERATOR

By means of the lightning generator in the high-voltage Laboratory of the Pittsfield Works, a great deal of information in regard to the effects of lightning on transmission systems was secured.

The potential of lightning approximates 100,000,000 volts or about one million times the voltage of the ordinary lighting circuit or one thousand times the voltage of a high-voltage transmission line. The current in the lightning flash may be 80,000 amp. and the energy 13,500 kw-sec. or 3.8 kw-hr. Since this energy is dissipated in a very short time, the power may be several thousand million kilowatts or horse power.

The experiments were conducted with artificial lightning on models of clouds, Fig. 57, built to scale, the voltage of the lightning generator being about two per cent and the power about two-hundredths per cent of natural lightning. This practically corresponds to the lightning energy that appears on transmission lines.

A lightning flash in the vicinity of a transmission line may cause dangerous voltage on the line. The line is very seldom directly struck, the effect generally being caused by induction. The line as well as the atmosphere around it becomes electrified by the cloud and the charge on the line is released when the cloud discharges to ground. The voltage on the line reaches its maximum at about the time the cloud voltage reaches zero.

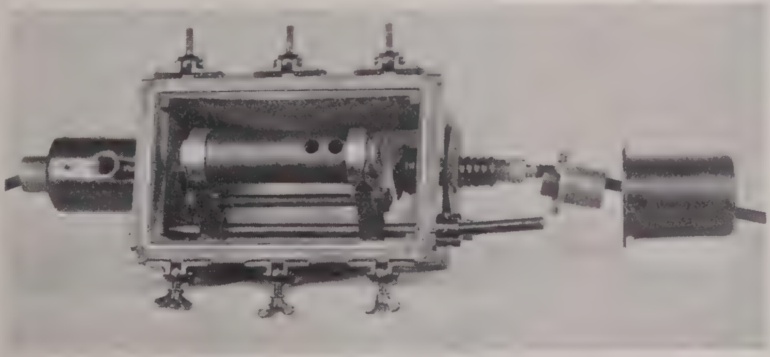

Fig. 56. Interior View of a 15,000-volt, 200-amp., Explosion-chamber, Subway-type, Combined Oil Fuse Cutout and Switch

It was found that a grounded wire placed near the line conductors reduces lightning voltages on transmission lines to less than half. Several ground wires reduce the lightning voltages still more. The ground wire was also demonstrated to be a good protector against direct strokes.

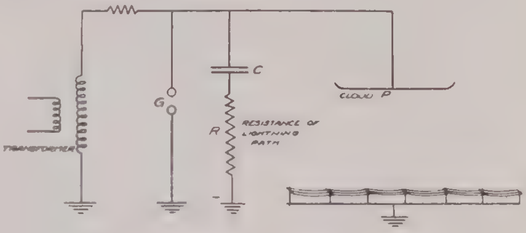

Fig. 57. Diagram of Artificial Lightning Testing Equipment

The strength of the insulation of lines operating at various voltages was also determined by measurements with artificial lightning, and by comparing the insulation strength with the maximum lightning voltage the ability to withstand lightning was determined.

The insulation of transmission lines is increased with the operating voltage; and the higher the operating voltage, the better is the insulation able to withstand lightning voltage. Special precautions must be taken, however, to cause the lightning voltages to divide evenly over the apparatus.

Researches showed further that lightning from a cloud overhead does not always strike the highest object unless the height of that object is over 2.5 per cent of the cloud height. The division of hits is about equal between object and ground when the object is 1.1 per cent of the cloud height.

Under certain conditions lightning may cause sparks within metal tanks.

X-RAY TUBES

The cooling system, whereby circulating water is carried directly to the back surface of the anodes of x-ray tubes, was standardized so that the 250,000-volt, 50-milliampere tube outfits could for the first time be placed in commercial production. This tube still represents the maximum unit production of x-ray energy, and a number of outfits of this capacity have already been applied in research and manufacturing processes as well as therapeutic work.

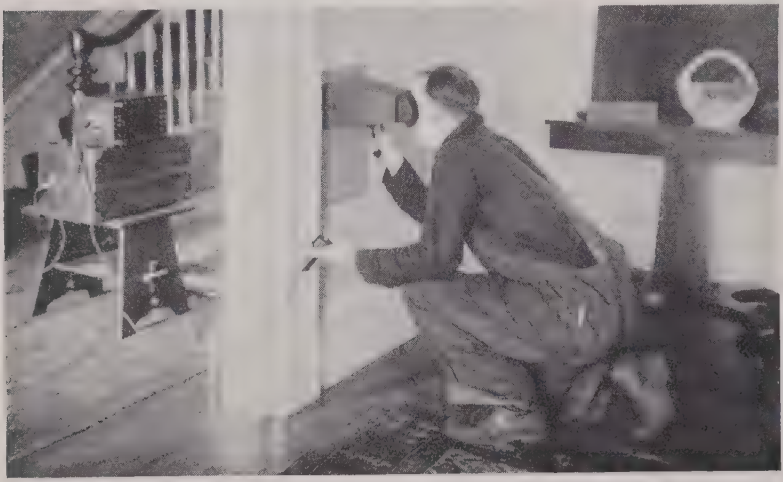

Fig. 58. Portable X-ray Outfit Used to View the Interior Arrangement in a Wall

In contrast to this large tube, the production of a very small x-ray tube made possible a complete self-contained portable x-ray outfit, weighing only 20 lb.

In this outfit the x-ray tube operates in the same oil and in the same container with a high-tension transformer, the complete equipment being encased in metal which obviates all high-voltage hazard to the operator. When alternating current is available, the outfit can be energized by connection to an ordinary lighting circuit.

By the development of this portable equipment, Fig. 58, the x-ray becomes practicable for a great variety of uses without requiring skilled manipulation. It can be used conveniently not only for therapeutic and dental work but for the making of photographs and the inspection of the interior of materials and structures, and can be handled safely by operators without any special training.

The x-ray is, therefore, no longer the dangerous laboratory adjunct, requiring careful manipulation, but is becoming a veritable portable tool of industry.

FUSED QUARTZ

By means of the electric furnace and the development of a process of production involving the use of high temperatures, high pressures, and high vacua, the Thomson Laboratory at the West Lynn Works was able to accomplish for the first time the production of clear fused quartz on a commercial basis. The mass of individual slugs so produced was also much greater than had been previously secured.

It is now possible to make more general use of this unique material and, therefore, a brief outline of its characteristics may be of interest. It has a melting point of 1715 deg. C. and its coefficient of linear expansion is the smallest of any known material. It is probably the most transparent solid substance, Fig. 59, and the only one producible in large amount that will transmit ultra-violet rays. It is also remarkably transparent to low heat rays and is superior to glass, porcelain,

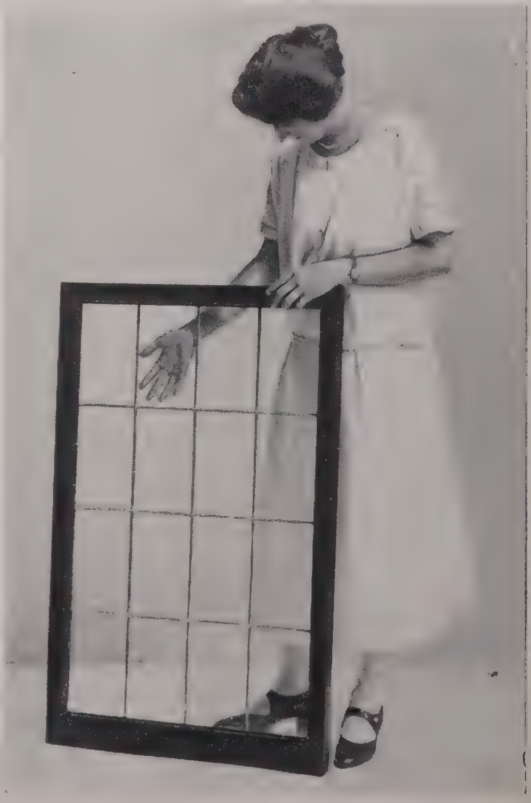

Fig. 59. Window with Panes of Clear Fused Quartz

and similar materials as an insulator, both on account of its mechanical properties and its great dielectric strength. It is unaffected by practically all acids except hydrofluoric and phosphoric acids, and by them only at a temperature of about 400 deg. C.

Clear fused quartz is probably the ideal material for astronomical mirrors, plane and concave, and can be more readily worked and shaped for this purpose than any other known material. In large masses this promises to be one of its great future applications.

Due to its low expansion (which assists the working very materially as compared with glass) fused quartz can be handled with the blow-pipe and shaped into many forms without fear of cracking.

RADIO

Transmitters were designed and built for the U. S. Bureau of Lighthouses, for use as radio beacon stations. These units, sometimes referred to as "fog-signal transmitters," are used in foggy weather to permit ships in the vicinity of the beacon station to take radio compass bearings, and to be warned of the proximity of the beacon station. In other words, a radio signal, in the form of one or two letters, constantly repeated, is utilized in place of the visual signal from a lighthouse.

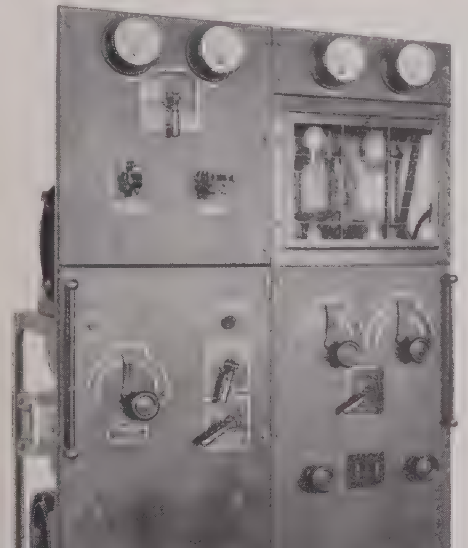

Fig. 60. Two-kilowatt Ship Radio Transmitter

For installation on ships, transmitters were produced which constitute the latest development in low-power tube-transmitter design. They have an output of 2 kw. in the antenna, Figs. 60 and 61, and are built to transmit either continuous-wave or sine-wave modulated signals. They utilize a new power tube having an output of 1 kw. and operating on a plate potential of 2000 volts direct current.

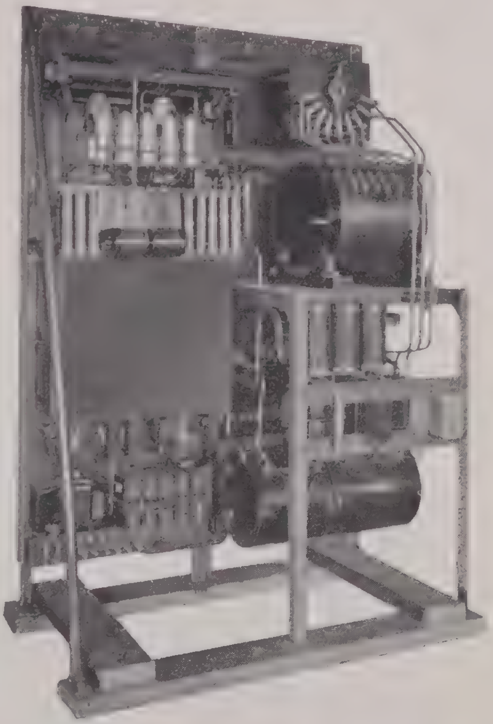

Fig. 61. Rear View of 2-kw. Ship Transmitter Set

Equipments were also provided, Figs. 62 and 63, for converting existing ships' spark transmitters (which are now practically obsolete so far as new installations are concerned) into continuous-wave transmitters. These attachments permit owners and operators of spark equipment to obtain the advantages of continuous-wave transmission, while still using a considerable portion of the original equipment.

The improvements in broadcasting equipment were centered on quality, increased output, and pick-up devices. The quality of the output of the broadcasting transmitters was improved to a point where ultra-sensitive receiving equipment and loud speakers indicate that the transmitters are faithfully reproducing the studio material.

Extensive tests were made to establish the merits of transmission at frequencies differing widely from those now in general use for broadcasting. Most of this work was devoted to transmission at very high frequencies, up to 20,000,000 cycles.

The results of this experimental work indicate that these frequencies hold some promise for radio relaying and for transmitting over great distances under certain conditions.

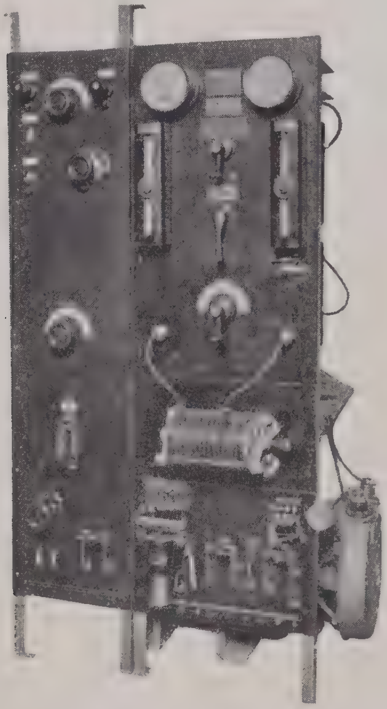

Fig. 62. Vacuum-tube Transmitter Attachment for Use with Spark Transmitter

Investigations were made into the cause of, and remedies were provided for, radio interference to broadcast reception caused by electrical devices. This work resulted in the elimination of a considerable amount of interference in areas from which reports of such interference had been received. The General Electric Company acted in an advisory capacity only and confined its activities to making recommendations, to the people concerned, which would reduce or eliminate interference in broadcast reception caused by their equipment. In numerous cases such recommendations brought about the elimination of serious interference.

Frequency multipliers and associated circuits for use with 200-kw. high-frequency alternators were developed to the stage of practical operation in a trans-Atlantic station. This work is expected to extend the usefulness of the high-power alternator equipments.

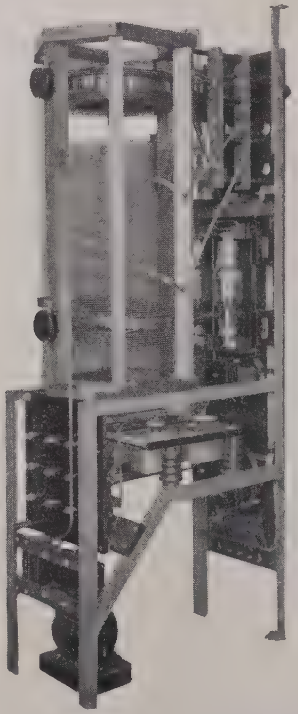

Fig. 63. Rear View of Vacuum-tube Transmitter Attachment for Spark Transmitter

An electron tube relay equipment was produced by which the 200-kw. high-frequency alternators may be satisfactorily controlled for telegraphy to a rate of 250 words per minute or about ten times the normal average rate of sending.

Two improved types of large antenna tuning coils, one for outdoor and the other for indoor service, when used with large antennas should greatly increase the efficiency of large radiating systems.

Investigations of the behavior of various insulations when subjected to high voltage at radio frequencies established many fundamentals of dielectric phenomena of considerable value.⑶

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(3) Developments in radio receiving during 1924, as reported by the Radio Corporation of America, appear in the article "Progress in Radio Receiving During 1924," on p. 59 of this issue.—Ed.

CARRIER CURRENT

A new standard high-frequency carrier-current station set embodies many improvements including interphase and single-frequency duplex operation and selective ringing. It is designated as the "multi-power" set because of the wide range of power output through which it may be operated to meet various conditions.

It consists, Fig. 64, of transmitter, receiver, and power panels, motor-generator with starter, protective equipment including drainage coils, choke coils, and hemisphere gaps, and operator's equipment including desk stand, call bell, loud speaker, and switch.

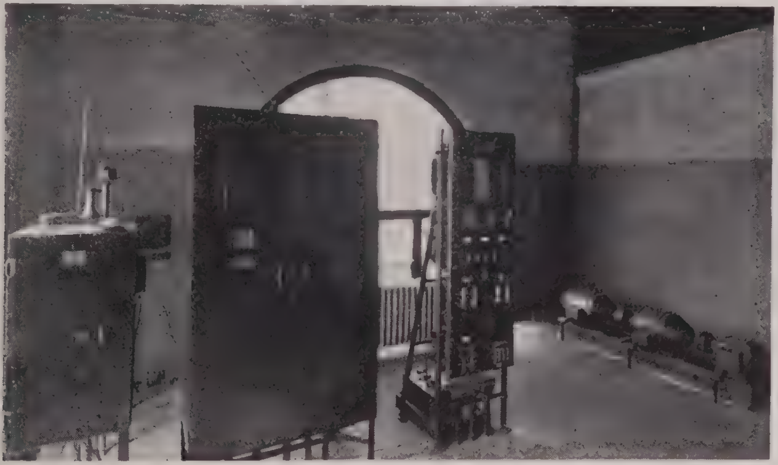

Fig. 64. Single-frequency Duplex, Interphase Carrier-current Telephone Equipment

After the multi-power equipment is installed and adjusted, the operations necessary to call are identical with those of the conventional automatic telephone, that is, the receiver is lifted and the station desired is dialed. When the called station responds, a two-way or duplex conversation may be carried on.

The outstanding advantage of the single-frequency system is that it provides the maximum number of non-interfering communication channels which is of such fundamental importance in the extended use of the carrier-current telephone on interconnected power systems. The single-frequency system is also the only one on which any number of stations can engage in a full party line conversation and with which light-weight portable equipment can be readily provided.

The carrier-current telephone now provides a telephone circuit having the physical reliability of the power circuit which is usually much greater than that of a wire telephone line. The carrier current goes even farther in providing communication as long as the transmission line provides a closed high-frequency circuit even though some of its conductors are entirely disabled. It is, of course, impossible to define clearly the many combinations of conditions under which this limiting situation occurs.

From the outset it became evident that, in order to meet the communication requirements of the central station, a carrier-current system must include a practical portable equipment for use on trucks and by patrolmen afoot. The introduction of the single-frequency duplex and interphase operation made this possible and there is now available a complete telephone transmitting and receiving equipment, Fig. 65, which weighs about 15 lb. and has the following approximate dimensions: height 10 in., width 9 in., depth 6 in. This equipment has a normal range of about 30 miles along a straight transmission line which is free from intervening taps or connections.

In the application of carrier-current control to various power practices, equipment was produced for the following typical applications:

The operation of circuit breakers from a remote point, using an existing line for the transmission of carrier impulses.

The system developed will open or close any one of a number of breakers, at the same time giving a positive indication of the position of each breaker at the operator's desk.

The operation of street lights at remote points. In this system, also, existing lines are used to convey the carrier impulses. The system can be made selective, so that lights in any one of a number of towns, for example, may be independently controlled.

Fig. 65. Portable, Carrier-current Transmitting and Receiving Outfit

ELECTRICALLY-OPERATED FLOW METERS

The principle governing the operation of the G-E electrically-operated flow meter⁽⁴⁾ was utilized to operate a variety of other instruments.

Two types of vacuum gauge were produced; one to indicate and record vacuum from 24 to 30 in. of mercury, and the other to indicate and record a vacuum from 0 to 30 in. of mercury. The same type of internal transformer element is used in the vacuum gauge as in the electrically-operated flow meter.

The end of the long U-tube terminating in the small funnel is open to atmosphere, Fig. 66, and the gauge body containing the internal transformer is piped to the condenser or vacuum producing apparatus. Mercury fills the U-tube up to the bottom of the small funnel. The suction in the gauge body causes the mercury to be deflected upward around the transformer element and to drop in the leg open to atmosphere, so that the unbalanced column of mercury will at all times balance the difference in pressure between atmosphere and vacuum. The indicating and curve-drawing electrical instruments are mounted on panels with calibrated scales.

The great advantage of this vacuum gauge over ordinary types is the fact that the indicating and curve-drawing instruments can be located at any distance from the condenser or apparatus in which vacuum is being measured, with wires connecting between the sending element and the instruments.

Electrically-operated gauges were designed for connection to tanks under steam pressure, Fig. 67, so that when the level of the water in the tank is the same as the level of the water in the reservoir, pressure on both sides of the electrically-operated gauge body U-tube is the same. When the water level falls in the tank, pressure is less on this side and the mercury will consequently be deflected upward in the transformer chamber

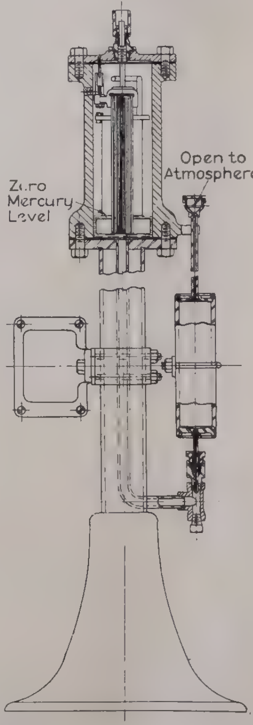

Fig. 66. Electrically-operated Gauge for Indicating and Recording Vacuum from 0 to 30 in. of Mercury

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(4) General Electric Review, January, 1924, p. 40.

until the unbalanced column of mercury balances the differential pressure. The indicating and curve-drawing electrical instruments will therefore measure the change of water level in the closed tank.

This water-level indicator is only applicable to tanks under steam pressure, where condensate will keep the reservoir and pipe connecting it to the meter full of water, and is not intended for application on boilers to measure the height of water unless used as auxiliary equipment in addition to the ordinary water glasses.

Water-level indicators and recorders utilizing the same principles of operation were designed for use with open tanks up to 18 ft. in depth.

TOTALIZING RECORDING WATTMETERS

Totalizing recording wattmeters were developed which operate on the induction principle; the record on the chart being nade by a pen connected through a simple inkwork to a moving element which is ubjected to rotational displacement. This noving element is a shaft some three feet ong on which are mounted four disks. Grouped about these disks are watthour meter elements so arranged that they cause to exist torque producing current in the disks.

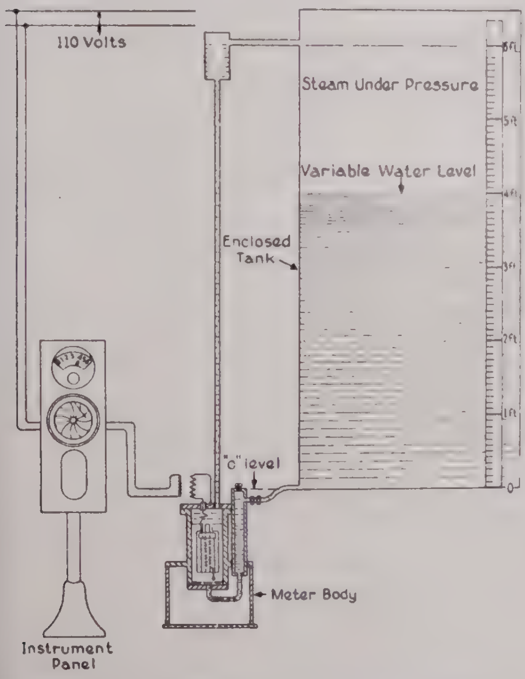


Fig. 67. Electrically-operated Water-level Gauge as Used with Tanks Under Steam Pressure

In order to totalize the power of several circuits it is necessary to use a number of watthour meter elements. As it is impractical to group all of these elements about one disk, they are grouped in fours, Fig. 68, about each disk. Each of these watthour meter elements is capable of adjustment with respect to a disk in such a manner that its torque on the movable element may be carried from maximum to zero. A motion such as this permits accurate adjustment of the watthour meter elements with respect to each other. This followed by an adjustment of the two main control springs assures the accuracy of the instrument over its scale which is evenly distributed from zero to maximum.

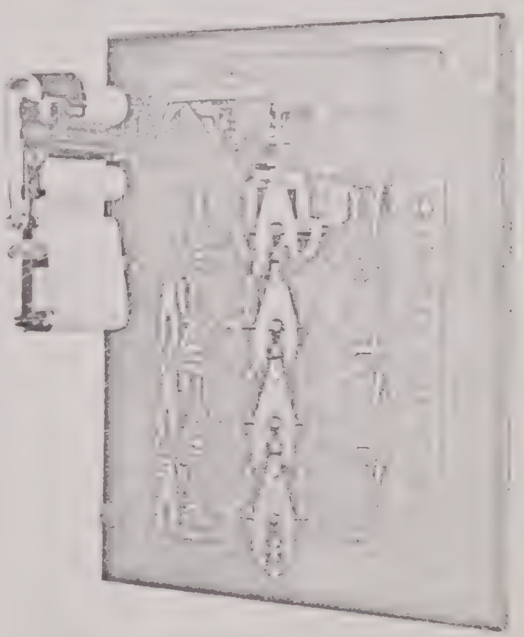


Fig. 68. Mechanism of Totalizing Recording Wattmeter

The motion of the moving element is damped by direct connection to a paddle moving in a sealed moulded bakelite chamber containing mercury, with the result that the chart record is a smooth line representing the average of the many little short duration fluctuations of power. These instruments have been built to totalize from one to eight circuits three-phase, three- or four-wire by the simple process of changing the external connections.

This makes possible an additional feature of considerable importance. Since the torque of all capacities of totalizing instruments is of the order of 3000 millimeter-grams, it is practicable to employ Selsyn generators and Selsyn motors in a system of remote indication. The small Selsyn generator is mounted inside the totalizing recording instrument. From this run three or five wires to small Selsyn motors located at points remote from the operating room. These Selsyn motors are so adjusted as to indicate on suitable dials the actual load as indicated by the totalizer. With the Selsyn system of remote indication it is possible that indicating apparatus, control apparatus, signal systems, and anything dependent upon the magnitude of the station load may be controlled directly and automatically from the totalizing graphic wattmeters.

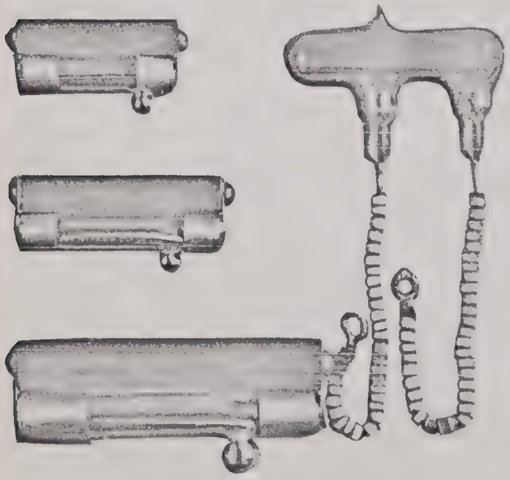


Fig. 69. Typical Mercury Connectors

MERCURY CONNECTORS

Glass enclosed mercury connectors were developed for use with various switch mechanisms for service where the usual copper or carbon-contact devices are unsatisfactory because of corrosive wearing of the contacts and variable contact resistance. These devices are sealed glass tubes containing mercury and an inert gas and having in-lead wires for the electrical connections.

These connectors cannot be properly called contact devices, as actual electrical connection is made through the complete physical union of the mercury poles, Fig. 69, rather than by a superficial contact of one metallic pole with another.

The effect of the glass enclosure and of the gas is to quench and extinguish the arc formed upon opening a circuit, in such a way that even on high current and high voltages there is scarcely more than an instantaneous flash and the interval during which the arc takes place is always much shorter than in any copper-contact device. What arc there is takes place between two mercury surfaces and in a gas which is inert relative to mercury, with the result that there is no corrosive action and the mercury surface remains clean and unaffected.

In switching devices equipped with these mercury connectors, the actual operation of making and breaking the circuit is done by gravity, that is, by the free flow of clean mercury in a glass tube. The only mechanical work required is simply the tilting of the glass container through the few degrees necessary to induce the mercury to flow from one end of the tube to the other.

The arc is quenched and the circuit broken by a gaseous medium whose properties are such that its insulating value varies but little with the distance between the mercury surfaces, with the result that in designing the switch for higher voltages it is not necessary to increase the bulk except insofar as the external electrical connections may be involved. In general, the angular movement necessary to produce a satisfactory separation of these mercury surfaces even on high-voltage switches need not be over 20 deg.

SWITCHING APPARATUS

Standardization work on outdoor stations was continued in two types of 66,000-volt equipments designed for this class of service; all exposed iron and steel parts are galvanized by the hot-dip process, all insulator units of the same voltage rating are interchangeable, and rigid tubular conductors are used for the main primary connections.

An industrial type of substation, Fig. 70, includes provision for the switching of power for a 13,200-volt incoming line and stepping down to 440 volts for power service and 110/220 volts for lighting service. A convenient means is provided for isolating the power transformers without cutting off the lighting service, and metering is provided for either individual instrument transformers or a combined metering unit. Accessibility to devices and apparatus for purposes of operation, inspection, and replacements is much better than in the usual type of closed structure. Lightning protective apparatus is included and the low-tension leads may be run into an adjacent building through pot-heads, underground, or overhead.

A complete new line of connectors and fittings for tubular conductors simplifies the work and materially reduces the cost of installing outdoor station bus structures, as all soldering and sweating of joints has been entirely eliminated. These connectors will carry the same current as the tubing to which they are attached, and will withstand any mechanical stresses to which they may ordinarily be subjected.

Complete self-contained steel units for central-station control were made of sheet steel with a steel framework, all welded into one structure.

In these units all equipment is mounted in place, with all auxiliaries such as relays and resistors installed on the inside, all interconnectors between equipment being included so that the complete unit, Fig. 71, is ready to be set in floor openings and put in operation by making the connections to terminal blocks near the bottom.

A triple-pole combined disconnecting switch and fuse was produced for 15,000-, 25,000-, and 37,000-volt circuits. It is designed so that the blowing of any one of the three fuse elements will actuate a tripping mechanism which opens all three switch blades simultaneously and prevents their reclosure until the fuses are renewed.

Instead of a separate mounting of the disconnecting switch and protective resistor

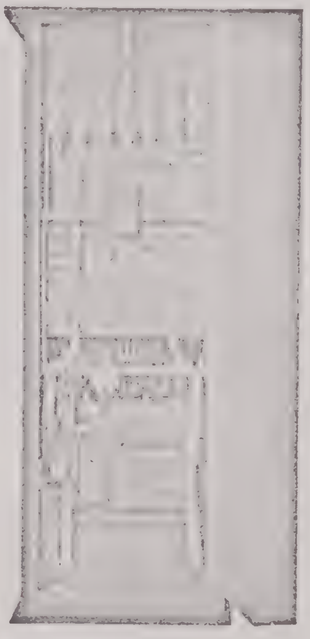


Fig. 71. Safety-enclosed Stationary Bench Panel (rear view) for Control of a 62,500-kv-a. Generator

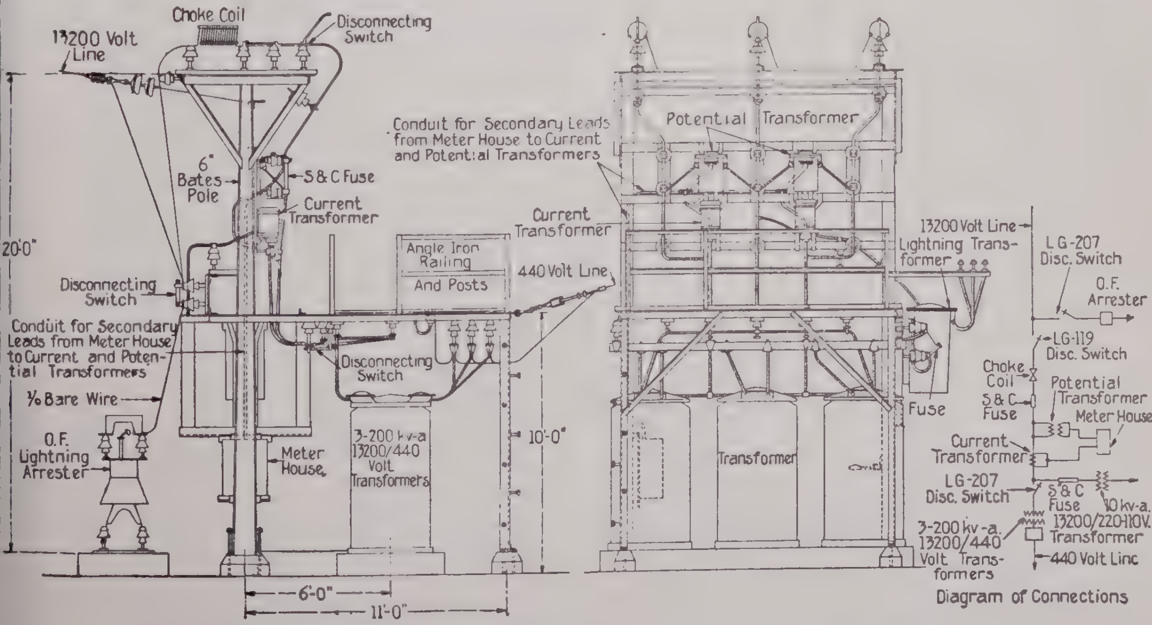


Fig. 70. Standardized Arrangement of Apparatus for an Industrial Substation

in the primary circuit of a potential transformer, a combined resistor and disconnecting switch, Fig. 72, is now available. It has jaw contacts such as those used on ordinary disconnecting switches but instead of the ordinary copper switch blade there is a wooden rod, and on it a porcelain insulator, on which is mounted a winding of suitable resistance and current carrying capacity for the particular line voltage, which may be 4500, 7500, 15,000, or 25,000 volts.

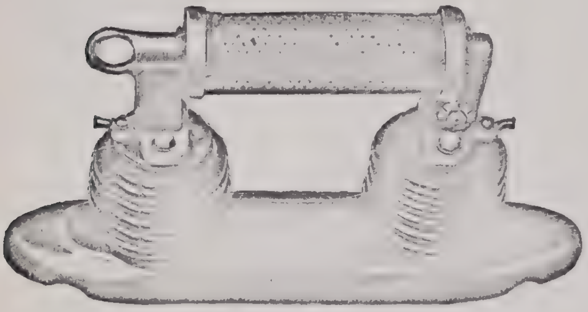


Fig. 72. Combined Disconnecting Switch and Resistor for 15,000-volt Potential-transformer Circuit

This resistor and disconnecting switch is sometimes combined with the transformer primary fuse, in which case the combination is mounted on three insulating posts. The combined resistor and switch is mounted between the first and second posts and the fuse between the second and third posts. The chief advantage of this combination is the elimination of the separate disconnecting switch.

Oil Circuit Breakers

In meeting the demand for a high interrupting capacity oil circuit breaker for indoor central-station use, the line of breakers previously in production was further improved and now covers voltage ranges of 15,000, 25,000, and 37,000 with interrupting capacities up to 1,500,000 kv-a.

This circuit breaker is assembled in standard triple-pole, single-throw arrangements. Each triple-pole breaker is made up of three breaker units, Fig. 73, the individual operating mechanisms of each unit being connected together and all operated simultaneously by the breaker operating device which may be a manual, solenoid, or motor mechanism.

The construction of the breaker is such as to take up the minimum space in the station, and the operating mechanisms are totally enclosed and mounted within the unit cover.

The higher interrupting capacities are provided with explosion-chamber and plunger contacts while those of lower interrupting capacities have finger contacts.

The breakers have been developed for standard framework or cell mountings, but are easily adapted to mounting on trucks or other arrangements.

The development of a new line of top-connected, Fig. 74, moderate interrupting capacity breakers of a standard-unit construction for indoor operation was practically completed. They are made for 15,000- and 25,000-volt circuits and for framework, cell or truck mounting.

The contact mechanism consists of main brush-type contacts and secondary arcing contacts. The brush contacts open first and close last when the breaker is operated. This arrangement insures the arc being broken on the removable secondary arcing contacts and relieves the main brush contacts from injury through the rupture of the arc.

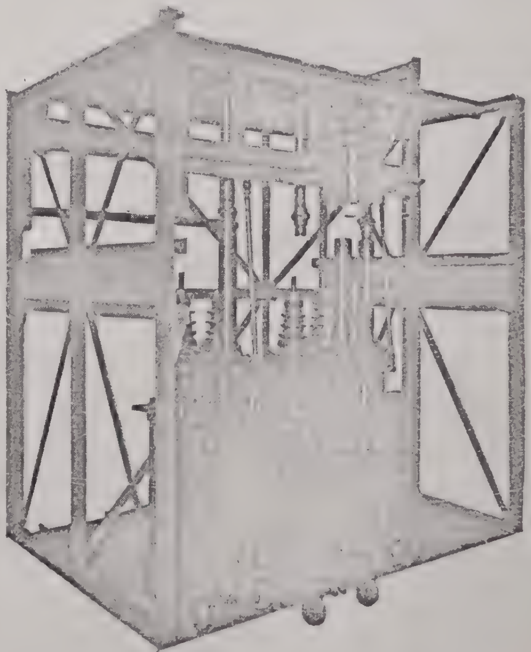


Fig. 73. Roll-out Type of Oil Circuit Breaker, Showing Arrangement for Three-pole Unit

The problem of increasing the interrupting capacity of oil circuit breakers already installed, without making radical changes in the station layout plans, was met by the production of an oil circuit breaker unit which gives an increase in interrupting capacity of approximately 40 per cent.

The overall dimensions of this unit, Fig. 75, are identical with those of the lower rupturing capacity unit which it replaces, except that the tank is somewhat higher. This of course makes it necessary to raise the cell tops, lengthen the tie rods of the old cell structures, and build up the cell walls to the required height.

Radical improvements were made in the design of motor-operated mechanisms for oil circuit breakers in which a small vertical type motor operates over wide variations of voltage both on alternating-current and direct-current circuits. It has a series characteristic which enables the mechanism to operate speedily and with great force at the beginning of the closing stroke. The fly-ball linkage driven by this motor is so constructed as to give a cushioning effect at the end of the closing cycle, and the tripping device is designed to trip free in case the breaker is closed on a short circuit.

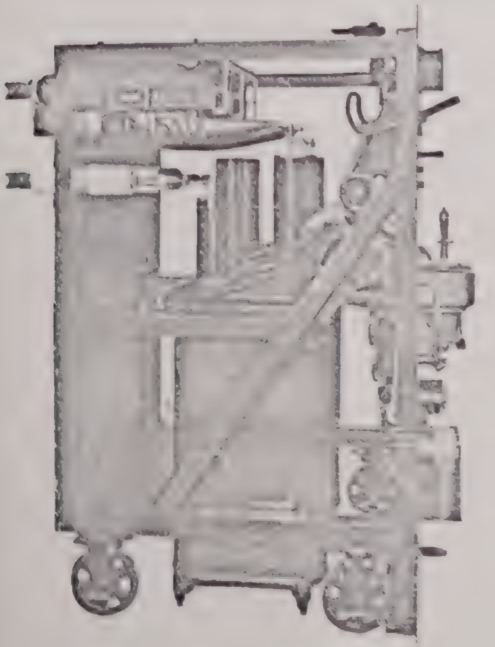


Fig. 74. Top-connected Moderate Interrupting Capacity Oil Circuit Breaker

The entire mechanism is small, Fig. 76, simply constructed but positive in its operation, and it is capable of operating any of the panel-mounted oil circuit breakers. A similar but larger mechanism was designed for breakers up to and including the 154,000-volt size.

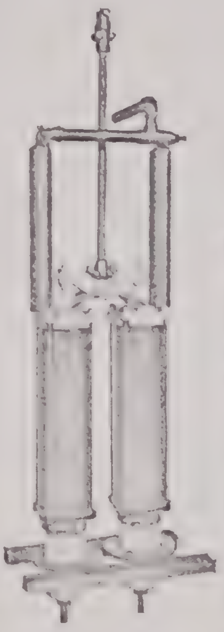


Fig. 75. Oil Circuit Breaker Replacement Unit

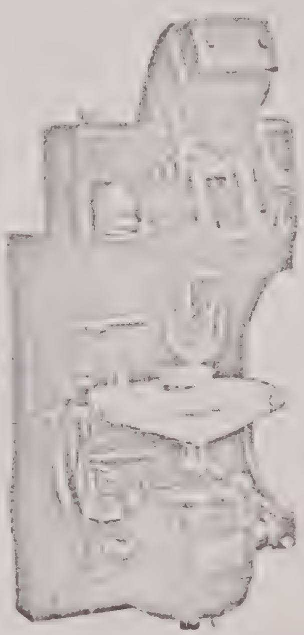


Fig. 76. Motor-operated Mechanism for Oil Circuit Breaker

Air Circuit Breakers

A new high-capacity air-circuit breaker, Fig. 77, for 250-volt direct-current service has a rating of 16,000 amp. at the main contacts and in addition has a neutral pole capable of carrying 4000 amp. It is designed to trip on reverse current only.

On the base is mounted a motor which is normally used only for closing the breaker main and neutral poles and a suitable link system, moved by the cam on the main shaft, carries the brushes from the open to the closed position. A magnet excited by a potential coil, called the "holding coil," attracts and holds an armature connected to the link mechanism, once the armature has been moved by the movement of the link mechanism against the holding coil magnet, in such a position as to maintain the brushes in the closed position.

Tripping is effected either by opening the holding coil circuit or shifting the field set up by the holding coil from the armature by means of an opposing field established by

reverse current in the "bucking" bar, which is a conductor part of and in parallel with the main circuit.

The contact brushes are arranged in "opposed" positions, so that when the breaker opens the field around the brushes tends to increase the speed of the opening operation.

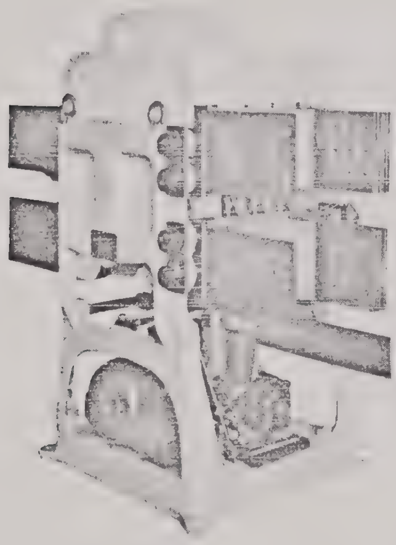


Fig. 77. Double-pole Motor-operated Air Circuit Breaker for 16,000-amp. Main Circuit

The neutral pole is insulated from the main pole; barriers separate the neutral and main poles, and the main and neutral conductors are insulated from the breaker frame and mechanism. An auxiliary switch for interlocking, lamp indication, or similar purpose, is connected by an adjustable link to the brush toggle, so that it may be actuated only when the brushes move from the closed to the open position and vice versa.

A fixed resistor unit is provided to limit the amount of current in the holding coil to a safe value at all times so that the holding coil may not burn out. There is also a small plate rheostat for calibrating purposes, and a limit switch with adjustable contact fingers is installed on the base near the cam at the end of the main shaft; the contact maker being mounted on but insulated from the main shaft.

Relays

A new timing relay for automatic station service, Fig. 78, is operated by a small but powerful squirrel-cage-type induction motor, through a train of planetary gears. When the timing operation begins, a clutch or holding magnet is energized which engages the moving gears and the contacts operate after a time-delay. At the expiration of the time setting, a lug on the rotating disk engages with a lever which trips the contacts.

By substituting different motor and clutch magnet coils, this relay can be used on either 110- or 220-volt circuits of all frequencies. The planetary-gear arrangement and graduated dial permit wide variation and fine adjustment of the time delay, which is inversely proportional to the frequency employed. On a 60-cycle circuit it may be adjusted from a minimum of 3 sec., to a maximum of 33 min., while on a 25-cycle circuit the minimum is 10 sec. and the maximum is 135 min.

An induction-disk motor-operated timing relay, Fig. 79, was designed for reclosing feeders at prescribed successive intervals. If the breaker remains closed after one, two, or three trials, the relay returns to its normal position and stops, ready for service when needed; but if the breaker opens again after the last reclosure it is locked open by the relay until inspected and reset by hand. The time of a cycle of the relay operation can be adjusted anywhere from 2 to 3 min. The three reclosures can take place as desired, at predetermined times during the cycle of the relay.

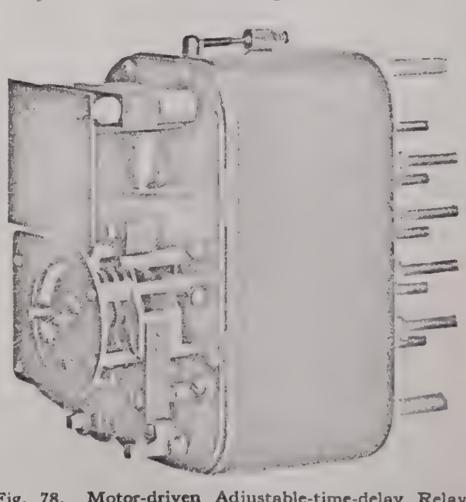


Fig. 78. Motor-driven Adjustable-time-delay Relay for 110- and 220-volt Circuits of Any Frequency

The contact arms on the large gear are counter-balanced, so that wherever they are set they do not produce irregularity of the timer speed. This relay combines the operations of two other devices previously used in reclosing.

A definite time plunger auxiliary relay introduces a long time (0.5 to 15 min.) in an operation. In one form, the relay solenoid is arranged for excitation from a direct-current and in another from an alternating current source. The long time is introduced by means of a large bellows and is adjusted as required by means of a long-time valve. The contacts, which are actuated with a quick action by means of a toggle, are for opening one and closing one circuit when the solenoid is excited. Standard windings are available for 220 volts, 60 cycles, and with series resistor for direct-current voltages ranging from 125 to 650 volts. The relay operates on any voltage above 75 per cent of rated voltage, and resets when the winding circuit is opened.

For accurate testing of the operating time of relays and other apparatus a timing device was developed, which comprises a miniature synchronous motor and a solenoid and plunger, mounted in a case, Fig. 80, like an instrument case. The dial and the binding posts (for connection to the motor and solenoid) and a knob for resetting the pointers to zero are mounted on a bakelite panel.

Fig. 79. Induction-disk, Motor-operated Timing Relay for Reclosing Feeder Equipment

The synchronous motor actuates two pointers, in appearance like the hands of a clock, which indicate the time of operation of the relay. The plunger is actuated by the solenoid, and, by means of a friction clutch, starts and stops the movement of the pointers at the beginning and end of the time that is being measured. Since the time measurement is in cycles of an alternating-current circuit, the indications of this timer have much greater accuracy than stop-watch indications, especially if the times are comparatively short.

Fig. 80. Synchronous Timer for Testing Operating Time of Relays

A differential-frequency relay was designed for use in connection with re-synchronizing synchronous motors of large lighting motor-generator sets.

An induction current-directional (reverse-current) relay was produced for protecting against grounds in a group of feeders all connected to the same bus, by selectively isolating the feeder in which the current flows to ground.

It consists essentially of an element like that in a single-phase power relay or wattmeter, except that the potential winding is replaced by a current winding. The relay on each feeder of the group has one of its windings connected to a current transformer, in the ground lead from the neutral of a bank of transformers (or other apparatus) in the vicinity. The other winding of the relay is in the residual lead of the secondaries of the current transformers of the feeder. Each of these windings carries a current representing the ground current. The relative directions of these two currents depend on whether the ground is in this feeder, or

at some other point on the system. Thus the relay operation is selective, and only the feeder having a ground fault is isolated.

A new polyphase-induction over- and under-power relay, with a rotatable knob outside the cover for adjusting the setting, has two induction elements, Fig. 81, corresponding to those in a polyphase wattmeter, for making the relay operate according to the polyphase power.

The two induction disks are mounted on a single shaft which is suspended on a torsion wire, and is held in correct position by a ring-jewel bearing. The torsion on the wire is varied, and the indicating dial is rotated, by rotating the external knob which is mounted on a shaft that projects out of the relay through one of the glass windows. This adjustment is for varying and indicating the power value at which the relay operates.

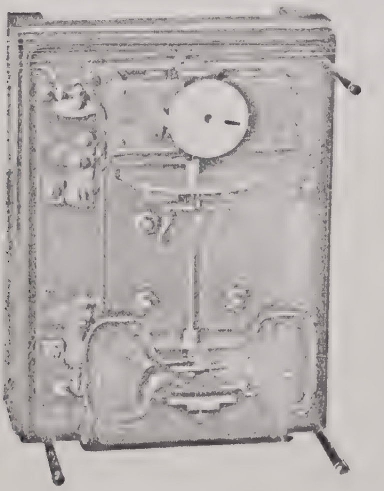


Fig 81. Polyphase, Over- and Under-power, Adjustable Relay

When the shaft rotates in one direction, due to over-power, it closes one contact, by which the power may be reduced, or any other desired operation may be performed. When the shaft rotates in the other direction, it closes the other contact, for increasing the power or performing some other suitable operation. On account of its very small friction and strong torque, this relay controls its circuit with great accuracy.

In a new form of hinged-armature auxiliary relay for use on alternating-current circuits, Fig. 82, the magnetic circuit is laminated and the pole faces are shaded, to produce quiet operation with alternating-current excitation. The relay has silver-to-silver self-aligning contacts with a double break, and gravity and spring action co-operate in the resetting, so that when the relay operates the contact is good and when it resets the break is rapid and the gap is generous.

The contacts, which are suitable for controlling either an alternating-current or a direct-current circuit, will close a current of 30 amp. and carry continuously a current of 12 amp. They will break 7 amp. on 125 volts direct current, or smaller currents on higher voltages; and they will break 20 amp. on 125 volts alternating current, or smaller currents on higher voltages.

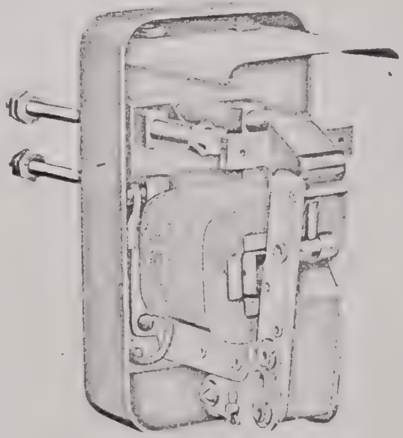


Fig. 82. Hinged-armature Auxiliary Relay for Alternating-current Circuits

In a modified form of another auxiliary relay, which is for series lighting circuits, double-throw contacts were provided, so that one circuit is closed and one is opened when the relay operates.

In the old form, the relay was used with or without a contactor, either to open or to close a constant-potential circuit, in order to turn on or off low-voltage lamps when the series lamps were turned on, and to reverse the operation when the series lamps were turned off.

In the new form, the relay can either turn on or turn off a circuit, or it can turn on one circuit and turn off another.

Changes were made in the mechanical design, Fig. 83, of two types of machine-temperature relays. The inherent characteristics were not changed but the relays and their auxiliary transformers which were previously mounted separately were combined into one device and the auxiliary transformer was equipped with a tap plate which facilitates the changing of connections. Mercury contact tubes were also utilized.

A temperature indicating relay was produced for actuating an alarm device when the temperature coil to which it is connected reaches a predetermined temperature. The equipment is in two parts: that on the switchboard which includes the indicating relay proper, and suitable resistors and switches; and that on the machine, which includes six non-inductive copper temperature coils, and a protective device consisting of six pairs of disk-film cutouts respectively connected between the several temperature coils and ground.

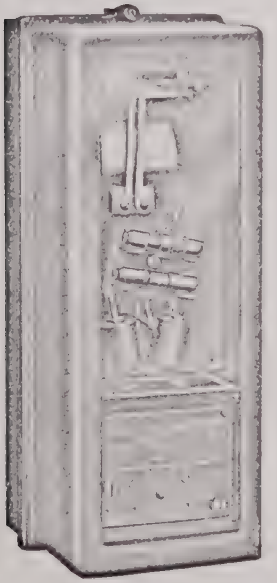


Fig. 83. Machine-temperature Relay

The indicating relay proper, Fig. 84, includes a differential d'Arsonval instrument, one of whose windings is connected in series with one of the temperature coils, while the other winding circuit has a negligible temperature coefficient of resistance. Thus the differential action depends on the resistance, and therefore on the temperature of the temperature coil, which is thus indicated on the dial by the pointer.

A sparking point is clamped at the desired position on the temperature dial, and when the pointer reaches that position a spark produced by a small transformer jumps across the gap. Resulting from the sparking current in the transformer secondary is a considerable increase in the primary current, which actuates a small relay, which in turn actuates an alarm, calling attention to the excessive temperature. The small relay and the transformers are included in the indicating relay and mounted inside its case.

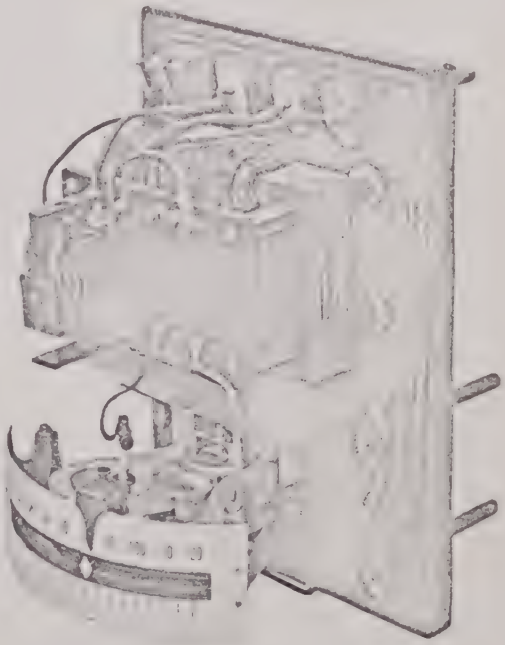


Fig. 84. Temperature Indicating Relay Embodying an Arrangement for Actuating an Alarm Device

The six temperature coils are arranged for connection, one at a time, to the indicating relay for finding the temperature of the machine or parts of the machine in which several coils are placed.

A new temperature relay consists essentially of a contact, an arm constrained by a spring to actuate the contact, and a small fusible alloy member restraining the arm from actuating the contact. When the fusible alloy is heated to its melting point

(97 deg. C.), it releases the arm, which immediately actuates the contact. The relay is reset by hand, after renewing the fusible member. It can be mounted on any approximately flat surface that will transmit heat to the metal base and thence to the fusible alloy member, and it is suitable for protecting against high temperature in laminations or other parts.

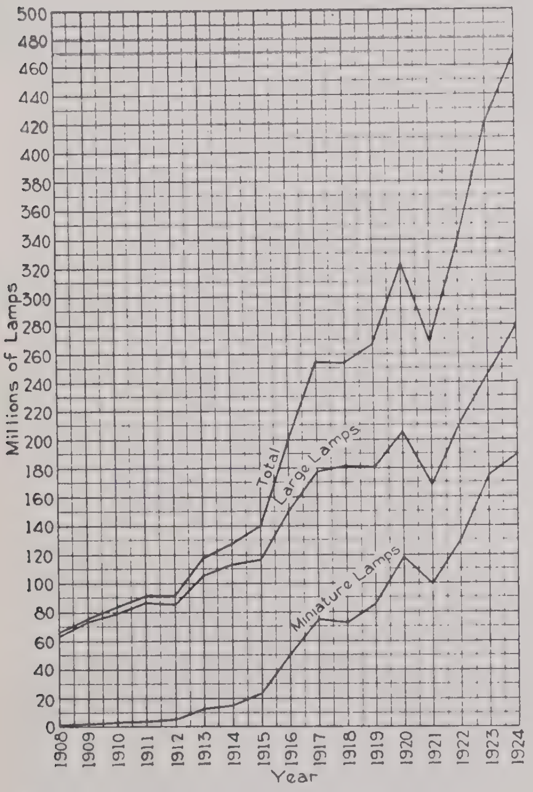


Fig. 85. Curves of the Number of Incandescent Lamps Sold in the United States, 1908-1924 (1924 estimated)

LIGHTING

The estimated number of incandescent lamps (excluding miniature, such as are used in automobiles, flashlights, etc.) sold in the United States during the year 1924 was 278,000,000. This is an increase of 33,000,000 or 13½ per cent over the previous year. The numbers of lamps sold during the past 16 years is shown diagrammatically in Fig. 85, and it will be noted that during the past year more than 4½ times as many lamps were purchased as in 1908. As the wattage of the average lamp sold in 1924 was slightly greater than that of 16 years ago, it is estimated that the number of kilowatt-hours consumed for lighting was about five times that of 1908. As the candle-power of the average lamp sold has about trebled, the aggregate amount of light now used is about 15 times that of 16 years ago.

The average price of standard lighting lamps is now one-third below their pre-war price. This remarkable reduction, Fig. 86, in the face of higher labor and material costs, is due to the development of improved lamp making machinery, Fig. 87, which has doubled the number of lamps made per operator and tripled the capacity of factory floor space.

The estimated number of miniature lamps sold in 1924 was 210,000,000, an increase of about 20 per cent over the previous year. The demand for the various types of miniature lamps was divided approximately as follows: two-thirds for automobile service, one-sixth for flashlight service, and one-sixth for Christmas tree decoration.

There were several changes in miniature lamps. The 2-c-p. rear, side, and instrument lamp for automobiles was replaced by a 3-c-p. lamp having a coiled filament. The new lamp is not only higher in candle power but due to the coiled filament is mechanically stronger, and is operated at a slightly higher efficiency.

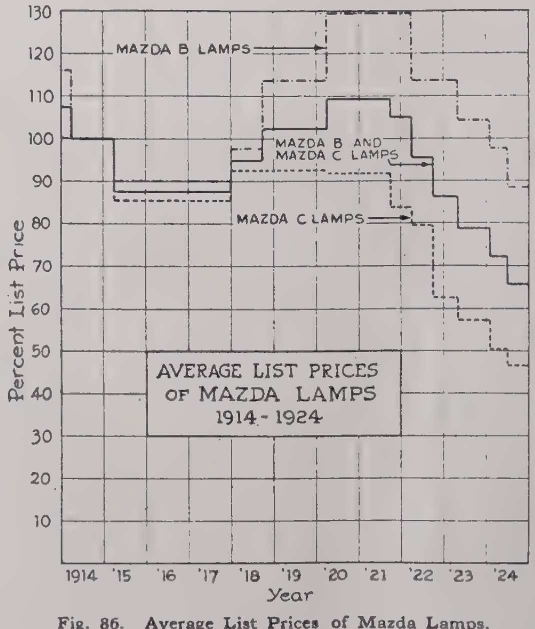


Fig. 86. Average List Prices of Mazda Lamps, Showing Recent Reductions

An increasing number of automobile headlight bulbs made with daylight blue glass appeared on the market, and while this lamp has no particular merit from the point of view of reducing glare, or improving the driving light, it gives the headlights a distinctive appearance. As the absorption of light by the blue bulb is about 33.3 per cent, it is necessary to use a 32-c-p. filament to obtain a 21-c-p. lamp.

Some experimenting was done with a double-filament headlight lamp having two filaments each of 21 c-p.; one located above the focal point of the reflector, and the other below it. By switching from one to the other, the beam may be projected far down the road for general driving or thrown on the near foreground for passing approaching cars.

The automobile voltage survey was continued; socket voltage measurements at various speeds, battery tests, running loads, etc., were studied on many cars; the result showing that the average socket voltage is gradually increasing. Accordingly, the design voltage of the 6-8-volt headlight lamps was increased from 6.35 to 6.5.

Considerable effort was devoted to narrowing the limits of variation in filament position in the concentrated-filament flashlight lamp. This resulted in better concentrated and hence farther reaching spotlights.

Experimental installations of primary-battery-operated Mazda lamps were made to replace some of the oil river lights used by the U. S. Lighthouse Department. These Mazda lamp outfits, Fig. 88, not only gave better illumination but also effected a considerable saving in operating cost.

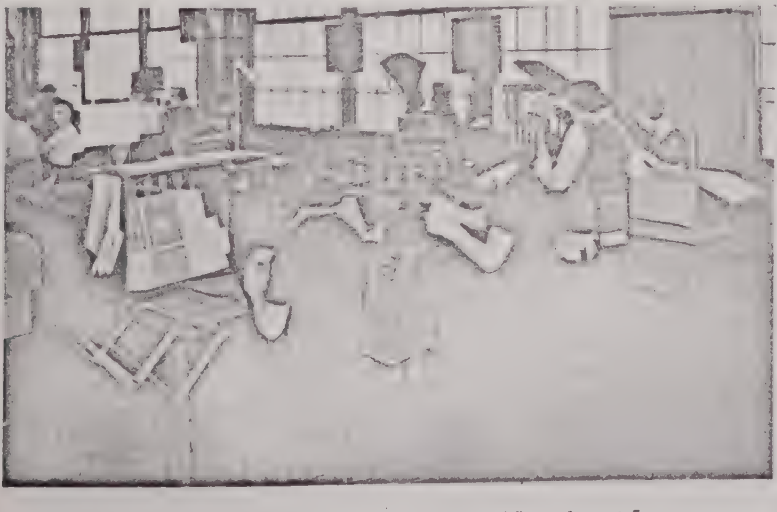


Fig. 87. Unit Machine for the Manufacture of Incandescent Lamps

There was an increasing agitation against the use of open flame lamps in the mining industry and such lamps are rapidly being replaced by storage-battery-operated Mazda lamps. The latest lamp in this field is a 1.8-volt, 0.9-amp. unit, made for use with jelly-electrolyte batteries. There was also a notable increase in the use of higher candle-power mine lamps for underground illumination.

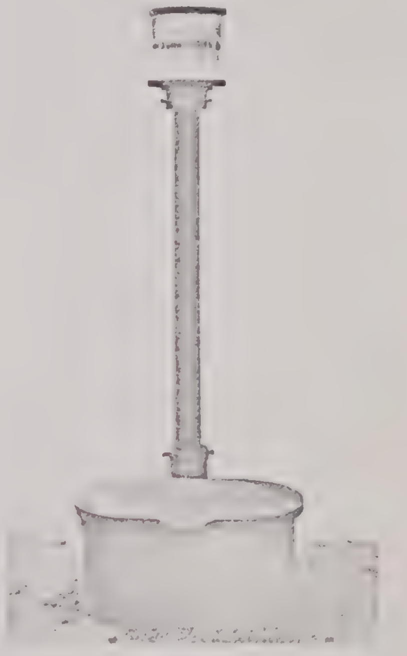


Fig. 88. Primary-battery-operated River Beacon

A new dust-proof unit for industrial plants consists of a cast-iron top with a felt globe seat. The globe, while rather odd in shape, Fig. 89, is all one piece of glass, the sides of which are silver plated and covered with a coating of copper. The bottom is clear rippled glass. This unit is very efficient and at the same time it is not hard on the eyes because of the rippled glass on the lower part. When the globe is in place, it rests

on the felt globe seat and dust cannot enter.

Another new dust-proof unit consists of a porcelain-enameled steel reflector fitted with a hammered, wired-glass plate over the bottom, the whole comprising a heavy-duty unit, Fig. 90, especially suitable for the lighting of steel mills and foundries.

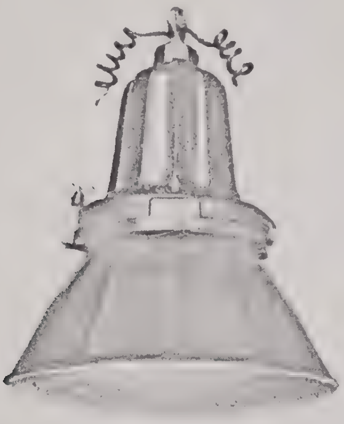


Fig. 89. Dust-proof Industrial Lighting Unit

Special 10-kw., 110-volt lamps, Fig. 91, were installed at the landing fields of the U. S. Night Air Mail Service. These high-wattage lamps necessitated the development of a special two-prong base, as the ordinary screw base with one center contact could not safely carry the high current required. A battery-operated beacon using small flashlight lamps was designed for route markers; and small Mazda lamps operated by three-cell primary batteries were also utilized for boundary markers at the various landing fields. Generators were added to the airplane equipment for the operation of wing tip landing lights.

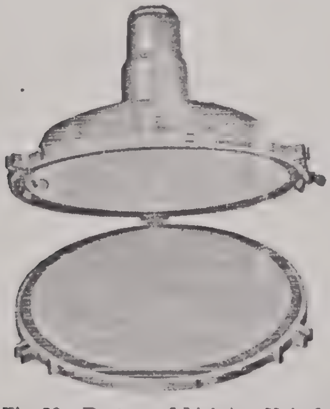


Fig. 90. Dust-proof Lighting Unit for Steel Mills and Foundries

Steady progress was made in the development of ribbon filament Mazda lamps. By their use microphotographs of exceedingly high magnification, and of fine quality, were produced which secured the award of the gold medal of the London Microphotographical Society. A special type of high-power spotlight was also designed to adapt the ribbon filament lamps to general theatrical work in place of the present high-power arc spotlights.

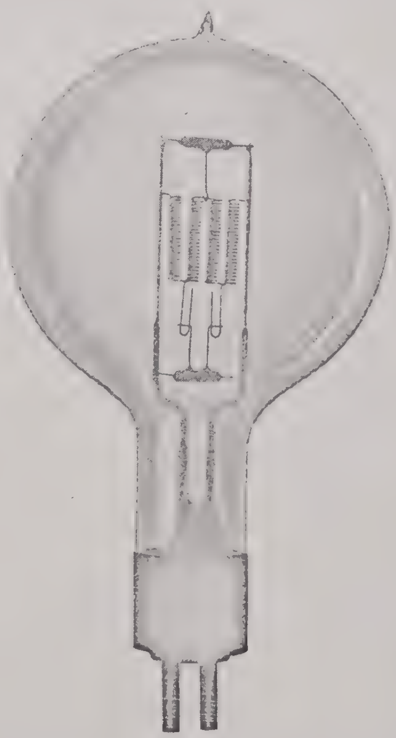


Fig. 91. A 10-kw. Lamp with Two-prong New-type Base for U. S. Night Air Mail Service

A marked advance was made in the number of small lamps manufactured for surgical and dental instruments and efforts were made for the reduction of the number of types of these lamps, and the production of a standard line.

During the year photographs of exceptional quality were transmitted by radio, Fig. 92, through the use of a small high-speed Mazda lamp and the transmission of photographed messages by radio, Fig. 93, on a commercial basis became feasible.

Since 1910, the standard of light, that is the International Candle, has been preserved in incandescent lamps, maintained at the

U. S. Bureau of Standards and certain European national laboratories. It is, of course, desirable to have a primary standard reproducible from specification, and to this end there has been almost continuous research to provide a primary standard comparable in accuracy with the incandescent lamp standard. An American scientist has now reported a primary standard that bids fair to meet this condition. It is based upon the light from a black body at the melting point of platinum, the black body effect being produced by forming a platinum fuse into the shape of a cylinder, with a longitudinal slit along one side.

Considerable laboratory experimentation was carried on with gaseous light sources in the search for practical methods of light production, and there seems to be an increasing probability of the development of useful illuminants of this type.

The Engineering Section of the Research Council, in coöperation with the Illuminating Engineering Society, undertook an extensive investigation of industrial lighting to determine the relation of illumination to employees' welfare and to production. The tests are expected to extend over a period of about two years, and to cover the subject thoroughly as the data previously available, while indicating considerable benefit from good illumination, were rather fragmentary.

The School Lighting Code of the Illuminating Engineering Society was revised and made more definite and comprehensive and was accepted by the American Engineering Standards Committee, as an American Standard, under the joint sponsorship of the American Institute of Architects and the Illuminating Engineering Society. It includes a series of rules, somewhat similar in form to those of the Industrial Lighting Codes, and is supplemented by sections explaining why good lighting is essential and how to provide it, both for natural and artificial light.

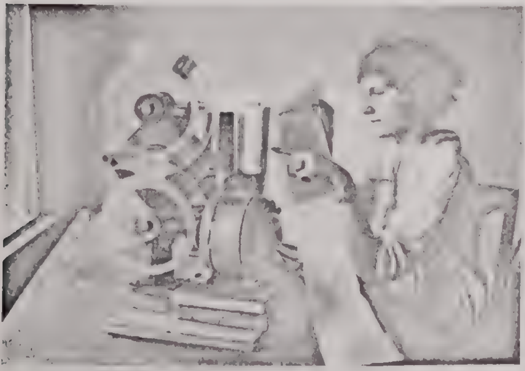
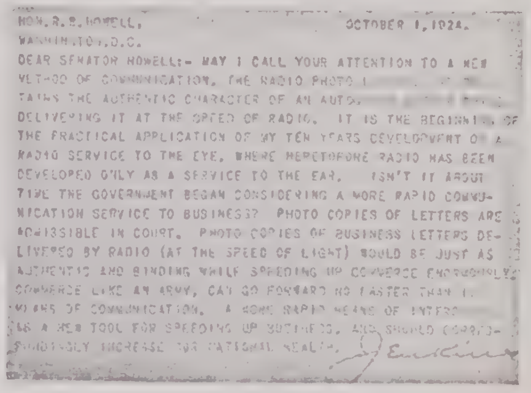


Fig. 92. Machine for Transmitting Typewritten Copy by Radio

During the year the state of Washington adopted an industrial lighting code, so that such codes, based on the American Standard, are now in effect in ten states representing a population of 42 millions.



HON. R. B. HOWELL, OCTOBER 1, 1924.
WASHINGTON, D.C.
DEAR SENATOR HOWELL:- MAY I CALL YOUR ATTENTION TO A NEW
METHOD OF COMMUNICATION. THE RADIO PHOTO [illegible]
TAINS THE AUTHENTIC CHARACTER OF AN AUTO[illegible]
DELIVERING IT AT THE SPEED OF RADIO. IT IS THE BEGINNING OF
THE PRACTICAL APPLICATION OF MY TEN YEARS DEVELOPMENT OF A
RADIO SERVICE TO THE EYE, WHERE HERETOFORE RADIO HAS BEEN
DEVELOPED ONLY AS A SERVICE TO THE EAR. ISN'T IT ABOUT
TIME THE GOVERNMENT BEGAN CONSIDERING A MORE RAPID COMMU-
NICATION SERVICE TO BUSINESS? PHOTO COPIES OF LETTERS ARE
ADMISSIBLE IN COURT. PHOTO COPIES OF BUSINESS LETTERS DE-
LIVERED BY RADIO (AT THE SPEED OF LIGHT) WOULD BE JUST AS
AUTHENTIC AND BINDING WHILE SPEEDING UP COMMERCE ENORMOUSLY.
COMMERCE LIKE AN ARMY, CAN GO FORWARD NO FASTER THAN I[illegible]
MEANS OF COMMUNICATION. A MORE RAPID MEANS OF INTER[illegible]
[illegible] AS A NEW TOOL FOR SPEEDING UP BUSINESS, AND SHOULD CORRE-
SPONDINGLY INCREASE OUR NATIONAL WEALTH.

Fig. 93. Message Photographically Transmitted by Radio

The variety of lighting practice followed by different railroads in the country, and the lack of an official publication describing the best practices, prompted the Association of Railway Electrical Engineers to make a study of this subject with the intention of publishing the material in the form of a "Lighting Manual" for the guidance of electrical men in the railway field.

Investigation of the drawing power of light in show windows was continued during the year. In one instance, the lighting of four windows along one side of a city street made a considerable increase of the proportion of pedestrians on that side of the street. In fact, more people stopped to inspect the show windows than had previously traversed that side of the street. Further investigation was also made of the effectiveness of high-intensity illumination in show windows to overcome the interference due to external images reflected by the front glass. Interesting quantitative data were secured which will assist in improving the practice.

The use of polarized light to reveal strains in the structure of material such as bridge members and ship plates, is a new application which seems likely to assume considerable importance in the structural arts. A

number of investigators reported upon these phenomena during the year.

Investigations into the application of artificial light in stimulating plant growth are being carried on with increasing interest. The accumulating data, while indicating limitation in the field, also suggest economic possibilities of considerable importance. An interesting incident in connection with one investigation points out how far ordinary artificial illumination falls below daylight. In the endeavor to duplicate daylight, intensity calculations showed that the most efficient industrial reflectors and 1500-watt Mazda C lamps grouped as closely as mechanically practicable would not produce as powerful illumination as summer sunlight.

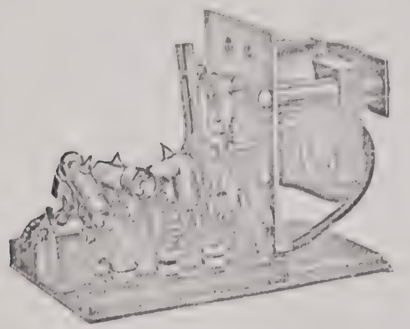


Fig. 94. Three-circuit Contactor for Automatic Traffic-signal Devices

A college laboratory made quite an investigation as to the most practicable illumination for poultry houses, to increase egg production. Its recommendation points out the advantage of conserving light by the use of reflectors, and also of providing sufficient illumination throughout the entire feeding and perch areas.

Electric Lighting was made an outstanding feature of the two great National Conventions at Cleveland and New York. Illumination experts of the lamp manufacturers and central-station companies were called in, and prescribed lighting which far excelled that of any previous convention.

A committee appointed jointly by the Conference of Mayors of New York State and the Empire State Gas and Electric Association made a study of the desirable trend of street lighting in the interest of economy and effectiveness. This committee recommended a standardization, in lumens per foot of street, for various classes of streets, and outlined certain other desirable characteristics of street lighting.

The entire Electric Lighting Industry of the country combined to support a Home Lighting Contest among the school children for the purpose of creating interest and providing instruction on better lighting. This was the most widespread and comprehensive activity of this sort ever undertaken.

The general plan was worked out and general facilities provided by a central committee representing all branches of the industry. The actual operation was left in the hands of local groups generally led by the central station.

Europeans are exhibiting increasing interest in American lighting practice. Early in the year a group of illuminating engineers, associated with lamp manufacturers, spent

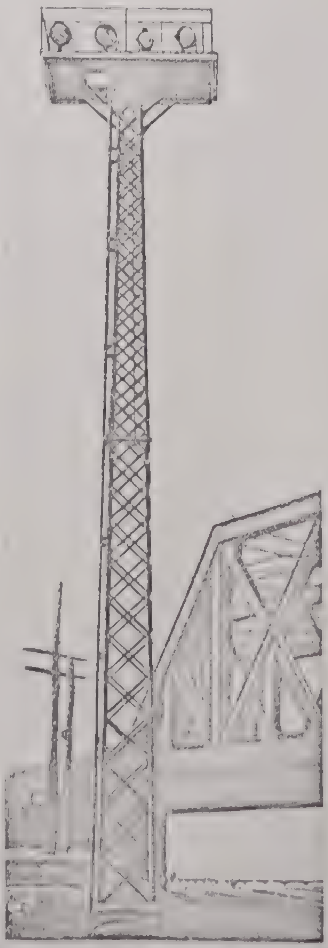


Fig. 95. Arrangement of Battery of Floodlights for Illuminating Railroad Yards

several months in this country studying methods and practices and subsequently an American illuminating engineer went abroad to assist them in adopting and applying the ideas under European conditions.

The International Commission on Illumination met at Geneva, Switzerland, and a number of important reports and papers were presented by American contributors. The next meeting will be held in the United States in 1927.

In order to meet conditions imposed by the constantly increasing density of street and highway traffic, a complete line of traffic signalling apparatus was designed with both manual and automatic control. Special weatherproof lighting units were provided both for ground and overhead signals, and for conditions where connection to electric circuits was impracticable, primary battery units were adopted.

The new multiple-switch automatic control devised for this service, Fig. 94, utilized mercury-connector switches actuated by a Warren clock motor.

Highway lighting was further extended but there were no changes in the lighting units adopted for this service.

Floodlighting

Over two-thirds of the gross income of our railroads is derived from the handling of freight, and as the movement of freight cars is a continuous performance, anything which tends to expedite this movement, decrease breakage and theft, and reduce the element of danger to the train operators is of importance not only to the railroads but also to our whole economic life.

Fig. 96. Typical View in a Railroad Yard Showing Floodlighted Area in Foreground

The Committee on Illumination of the Association of Railroad Electrical Engineers in November, 1923, reported the following advantages of yard lighting.

(1) Speeding up of cars handled in the yard at night time.

(2) Reduction in cars damaged by rough handling and collision in the classification yard with consequent reduction in claims, delay in delivery of goods, loss of service of damaged cars, etc.

(3) Reduction in losses due to pilfering on account of more effective policing possible with a well illuminated yard.

(4) Improved working conditions and increased safety for employees working in the yard.

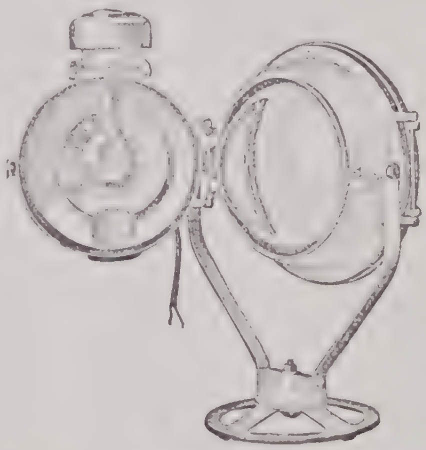


Fig. 97. Weatherproof Floodlight Projector for Railroad Yard Service

Certain railroads authorized relatively large expenditures for improved yard illumination and the subject was studied intensively by illuminating engineers.

The result was the production of floodlighting units particularly adapted to this special service and methods were devised for mounting these units singly or in groups, Fig. 95, to meet the widely varying conditions, Fig. 96, encountered in the size, shape, and traffic requirements of different classes of railroad yards.

The weatherproof projector developed for this service

Fig. 97, utilizes standard 110- or 220-volt, 300- to 1000-watt lamps with a simple focusing mechanism and shielded ventilating outlets at top and bottom. All materials used in its construction were selected to secure effective and long continued service despite the smoke laden atmosphere in which it must frequently operate.

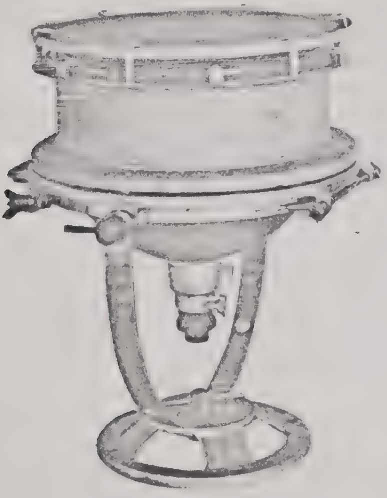


Fig. 98. Double-lens, Waterproof, Floodlight Projector for Electric Fountain

Further improvement was made in the use of floodlights for the illumination of athletic fields, to permit the playing of baseball, football, etc., at night. The location, elevation, number, and power of the lighting units required for different games were worked out in detail so that for each particular game a definite arrangement has been developed which affords ample illumination for rapid action on the part of the players without discomfort to the spectators.

A special type of waterproof floodlight projector, Fig. 98, was produced for the illumination of fountains. It has an auxiliary door, several inches from the inside lens, which holds a supplementary concave lens made of colored glass. This concave lens fills with water when the fountain is in operation and is thereby cooled sufficiently to obviate danger of cracking. Lamps of 500- or 1000-watt rating are used with either silvered or aluminum reflectors.

Street Lighting

More intensive illumination characterized the street lighting installations and a new unit consisting of two 6.6-amp. luminous arc lamps, Fig. 99, per pole was adopted for white-way service by Washington, D. C.; El Paso, Texas; Syracuse, N. Y.; and Schenectady, N. Y. Incidentally these lamps utilized a larger size of outer globe, Fig. 100, than had previously been produced commercially, and the arc was burned in an inner globe.

A serious study of street lighting requirements was undertaken by many city officials in an effort to plan for homogeneous lighting systems for different classes of streets and to define by ordinance the sizes of lamps, designs of fixtures, and types of poles or standards to be used. In general, four principal divisions were made: main business streets, secondary business streets, principal arteries of traffic, and residential streets, in all of which the lighting units will resemble

Fig. 99. Luminous-arc-lamp Installation on Erie Boulevard (formerly Dock Street), Schenectady, N. Y.

each other and differ only in size and intensity of illumination.

A demonstration of street lighting, extending over 2000 ft. of actual street, was installed in Cleveland, Fig. 101, so arranged as to permit the illustration of various levels of illumination, including some considerably in excess of those found in ordinary practice. It also illustrates the effect produced by varying different factors such as the hanging height and spacing. Forty circuits were provided for the current supply.

Supplementing this demonstration was a full-sized exhibit of a variety of ornamental street-lighting posts and fixtures.

There was evidence of the growth of the idea of super-white-way lighting in business districts which will carry levels of illumination far in excess of those commonly found. The city of Chicago planned an installation comprising two 2500-watt Mazda lamps (approximately 100,000 lumens) per post, the posts to be arranged opposite each other and spaced 120 ft. apart, which will result in the use of approximately 1800 lumens per running foot of street.

Probably the outstanding demonstrations in spectacular lighting during the year were the displays at the New York State Fair at Syracuse and the Brockton Fair at Brockton, Mass.

At Syracuse a design of volcanic peaks, Fig. 102, was festooned with glass jewels and

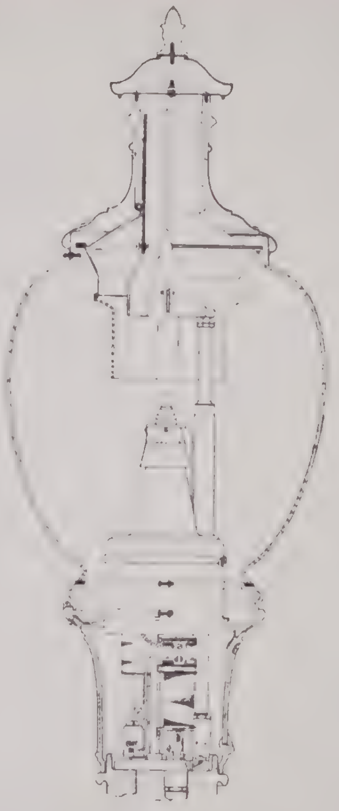


Fig. 100. Sectional Assembly of Latest Type of Luminous-arc Lamp

Fig. 101. "Forty Streets in One" at Cleveland, Ohio

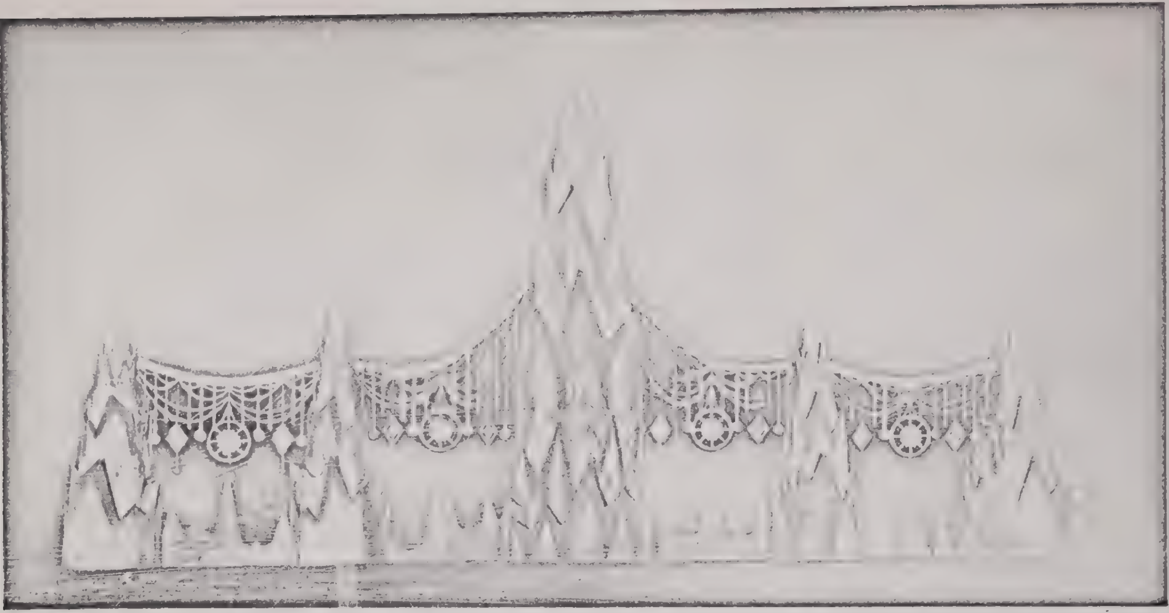


Fig. 102. Volcanic Peaks at New York State Fair, Syracuse, N. Y.

lighted by twenty-five 18-in. incandescent searchlights; each searchlight being equipped with a 12-volt, 100-amp. lamp.

In the jewelled spectacle at Brockton, Fig. 103, there were 30,000 jewels illuminated by a battery of thirty 18-in., one 30-in., one 36-in., and two 60-in., arc searchlights, which were individually manned and were used in beam drills and for the color illumination of fireworks and steam effects.

Another notable achievement in this field of illumination was the permanent lighting of the Caverns of Luray, at Luray, Va. Approximately 500 concealed lighting units, consuming 65 kw., now light three miles of subterranean splendor. Each of the great halls of colorful stalagmites and stalactites received individual treatment with colored lighting used in certain locations to accentuate effects.

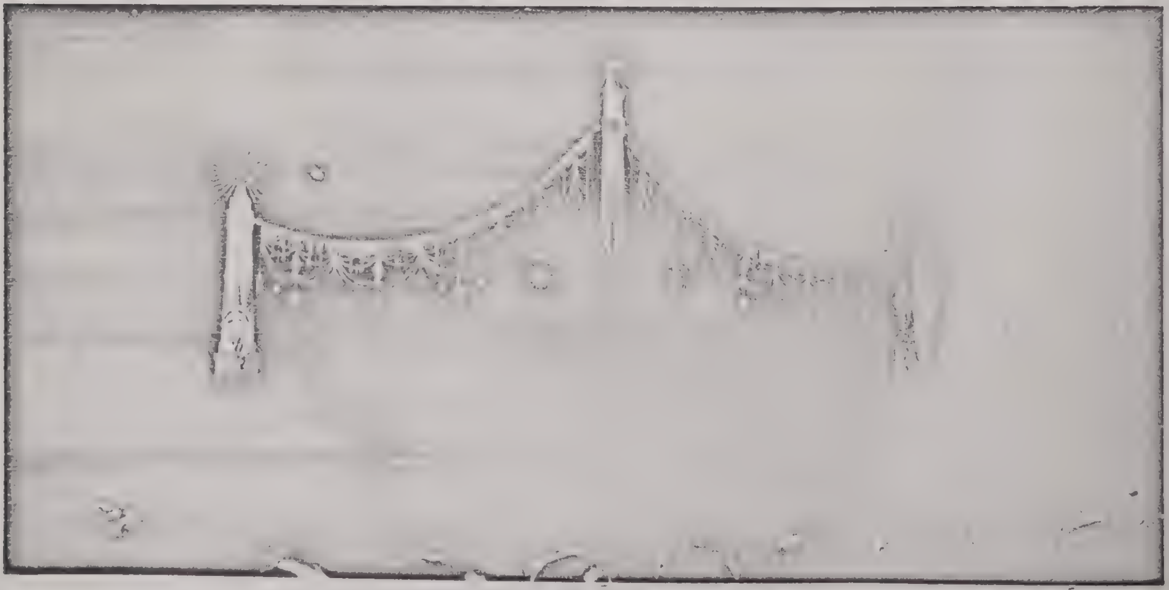


Fig. 103 Jeweled Arch Illuminated by Searchlights, Brockton, Mass.

Progress in Radio Receiving During 1924

By Alfred N. Goldsmith

Chief Broadcast Engineer, Radio Corporation of America

In this article, Dr. Goldsmith gives a brief account of the numerous significant advances in the radio receiving art which were realized during 1924. The many improvements which he outlines have come as the solutions to new and difficult problems raised by the rapid growth in the number of broadcasting stations and in the popularity of radio generally. The result has been that, in spite of the growing intricacy of circuits necessary to maintain high sensitivity and selectivity under the new conditions, the modern receiving set has become so reliable and so simple to manipulate as to bring it entirely within the service of even the most uninformed.—Editor.

The year 1924 was marked by outstanding improvements in the design of vacuum tubes, loud speakers, and radio broadcast receivers. The useful operating life of vacuum tubes was extended, the quality of loud-speaker reproduction improved and a gain was effected in selectivity and sensitivity of the receiving set. The production of the non-radiating regenerative receiver was a development of equal importance.

Vacuum Tubes

Standard types of three-electrode vacuum tubes have been improved in construction and performance. This has been accomplished without introducing radically new types of tubes. There are now available three types of Radiotrons, the filaments of which may be effectively heated by dry batteries. One of these types, the UV-199, has a thoriated-tungsten filament. Two other types, the WD-11 and WD-12, have oxide-coated filaments. A storage-battery tube of the thoriated tungsten filament variety has also been produced in large quantities, namely, the UV-201-A, and this has become the standard tube of this type. It is interesting to note that the power required for the filament of the dry-battery tubes lies in all cases between 0.18 and 0.27 watts. The thoriated-tungsten storage-battery tube has a filament consumption of 1.25 watts. This means that in representative receivers using dry-battery tubes, the filament power required is about one-sixth that required for modern high-efficiency storage-battery tubes, such as were common last year, and about one-thirtieth the power which was required for receivers with the same number of tubes two years ago.

The filament design has been improved so that it has become possible to obtain some overload capacity. Accidental abuse of tubes in service (employing excessive filament current) has far less serious results than previously in shortening the life of the tube. Accompanying this improvement in filament material, there is a considerable increase in useful life of the tube.

A characteristic of tubes which has hitherto not required attention is the input impedance. This factor, however, has an influence upon the behavior of certain types of sets which have recently been manufactured on a large scale. It has therefore become necessary to devise methods for controlling processes of manufacture so that the input impedance of tubes could be held within acceptable limits. This has been accomplished and the resulting tubes are therefore useful for all types of receiving sets. The application of the most modern quantity production methods of tube manufacture has made possible a price reduction of 38 per cent during the year.

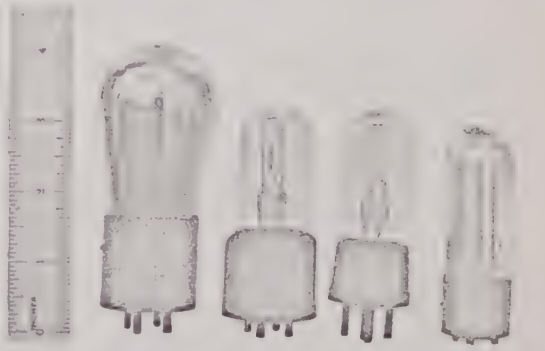


Fig. 1. Left to right: Radiotron UV-201-A, WD-12, WD-11, and UV-199

Fig. 1 shows the appearance and general dimensions of a group of present-day Radiotrons. It will be noted that these tubes have a new moulded material for the base and that they are tipless. In addition to giving the tube a more pleasing appearance, the avoidance of the tip lessens the chance of accidental breakage. The production of tipless Radiotrons has resulted from the introduction of the same manufacturing methods as are used in the production of tipless incandescent lamps, the technique of the lamp factory being available to the manufacturers of Radiotrons.

Receiving Sets

At the beginning of 1924, broadcast stations had multiplied to the extent that many receivers on the market were decidedly lacking in selectivity and were also strongly radiating. The new types of receivers (Radiolas) introduced in 1924 corrected these defects by eliminating radiation in all but the simplest and least expensive type of receiver. All were given adequate selectivity for their fields of application.

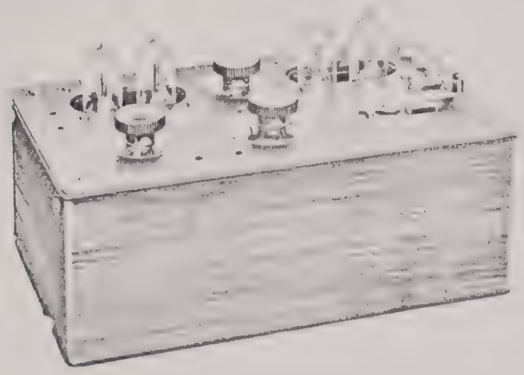


Fig. 2. Radiola III-A

In Fig. 2 there is shown the simplest form of regenerative receiver produced during 1924. In this receiver, design simplicity and large-production methods of manufacture have been employed to a degree never reached before and the resulting construction shows many ingenious and simple instances of the resulting benefits. For example, the telephone jacks of this receiving set, shown in Fig. 3, are formed from a single punched piece. No special plug is required, the telephone cord tips themselves acting as plugs when inserted into this jack. A double economy is thus obtained.

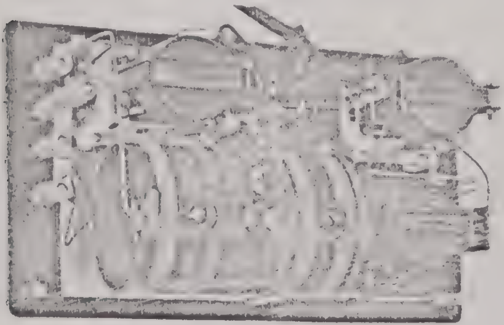


Fig. 3. Interior of Radiola III-A

The receiver shown in front and rear views in Figs. 4 and 5, is highly selective and non-radiating, and employs two tuned radio-frequency circuits and regeneration. This is the first set in which the advantage of regeneration has been obtained without the disadvantages which have been unavoidable previously, viz., radiation, and the reaction of one circuit of the receiver upon the other, which results in considerable difficulty of manipulation.

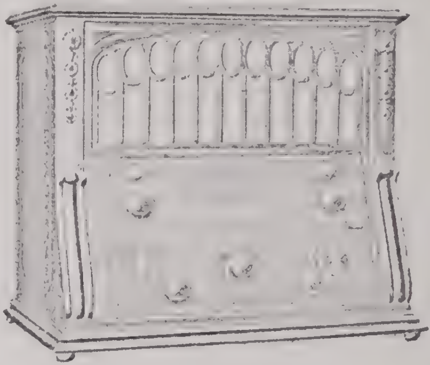


Fig. 4. Radiola X

Among the requirements of high-quality acoustic reproduction is the adequate response of the loud speaker to a wide range of musical frequencies. A common fault of loud speakers had been a relative lack of low-frequency response. This defect was avoided by the use of a special long horn and a particular receiver element which gave more low-frequency response and more pleasing sound reproduction. The introduction of such a horn into the set brought about design problems which were ingeniously solved, as may be seen from Fig. 5, by using a specially coiled horn fitted into the cabinet.

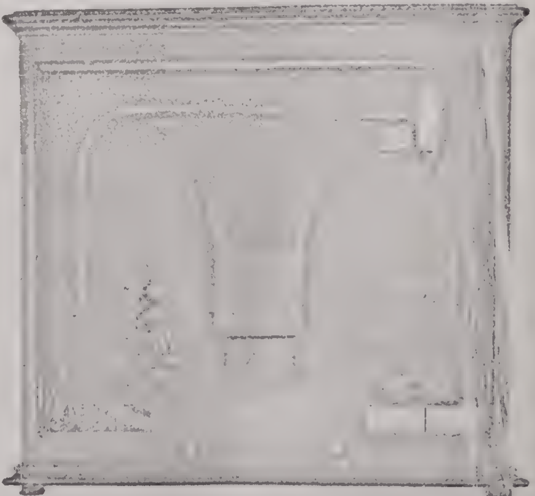


Fig. 5. Rear View of Radiola X with Back Removed

It is easily possible, even for unskilled persons, to pick up stations on regenerative receivers by throwing the receiver into the oscillating condition and utilizing the resulting beat note as an indication of the presence of the desired signal. However, this has been a frequent cause of radiation and resulting interference in neighboring receivers. In the form of circuit used in the receiver illustrated in Fig. 4, this simple method of pick-up is available but without radiation and local interference.

Perhaps the greatest advance of the year was the introduction of self-contained Radiola receivers, that require no outside connections to aerial, ground, batteries or anything else, and this without sacrifice of any of the performance characteristics of previous sets, and in fact with improvement in each one of these characteristics. The use of very small pick-up systems, such as are necessary if the receiver is to be self-contained, requires vastly greater sensitivity and a special circuit was developed which made these receivers possible.

This circuit is a modified and improved super-heterodyne which, although invented in first form about eight years ago, has not been utilisable in a form suitable to broadcast receivers, since too large a number of tubes was required and the operating characteristics were too complicated. The circuit put into manufacture during the past year utilizes a sufficiently small number of tubes to be practicable; simplifies the operation of the set sufficiently to permit its use by broadcast listeners having no technical knowledge of the art; gives a selectivity as great as it is possible to use in radio telephony; and, in general, comes very close to being the ultimate in broadcast reception.

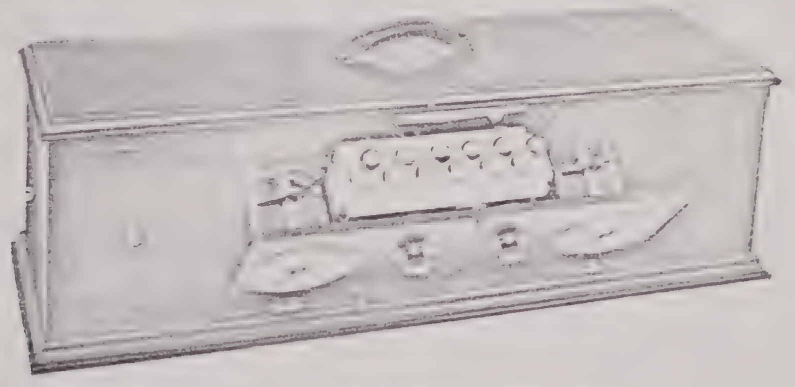


Fig. 6. Radiola Super-heterodyne with Panel Opened

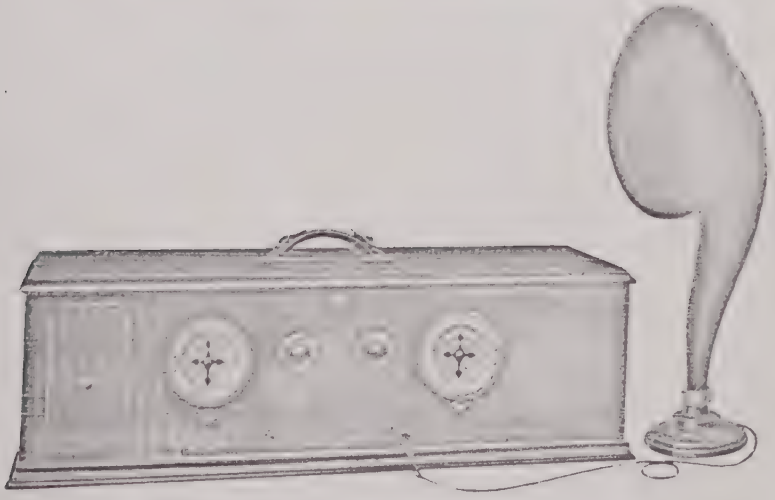


Fig. 7. Radiola Super-heterodyne with Radiola Loud Speaker

In addition to the fundamentally new circuit, the physical embodiment utilizes several radically new ideas of construction which have proved themselves to be very great improvements over preceding types of construction. Chief among these features is the enclosure of most of the component parts, such as transformers, fixed condensers, tube sockets, etc., in one metal box which, after assembly of the interior parts, is filled with wax. This has been popularly termed "catacomb" construction. It results in a solid unit (having a few terminals) which is not readily subject to damage, and which protects the parts from atmospheric effects and physical alteration which must be guarded against in sensitive radio apparatus material. As a result of this construction, which is employed in the receivers shown in Figs. 6, 7, and 8, these Super-heterodyne Radiolas have an apparent simplicity of appearance, although actually they are much more complicated and contain many more parts than any preceding receivers. These receivers have been designed with an external form having an appearance suited to high-class home instruments.

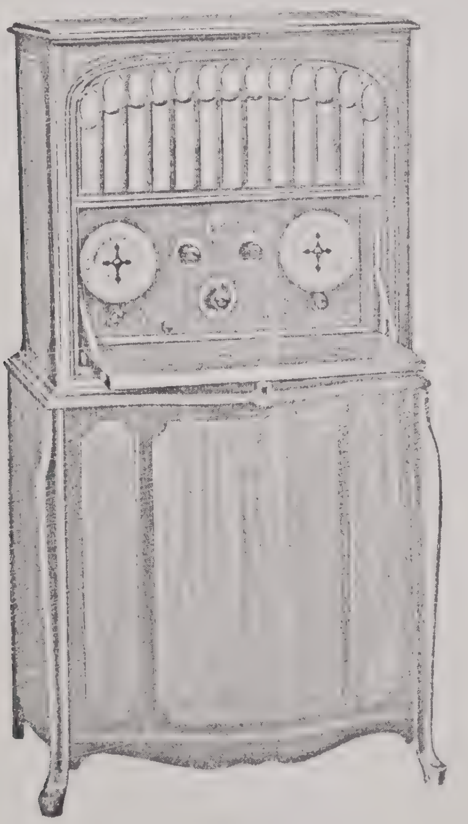


Fig. 8. Radiola Super VIII

The past year has, therefore, seen in the introduction of these receivers a most notable advance in all of the important characteristics of Radiolas; viz., appearance, sensitivity, selectivity, ease of operation, and quality of reproduction.

A well-designed radio receiver requires a proper association of suitable tubes, circuits, and loud speaker to make a device which is suited to the field of application for which it is designed; and in summary of the progress of the year in receivers, it can be said that not only have notable advances been made in each type of receiver, but a line of receivers has been developed and marketed such as to meet with one type or another every demand of the radio public.

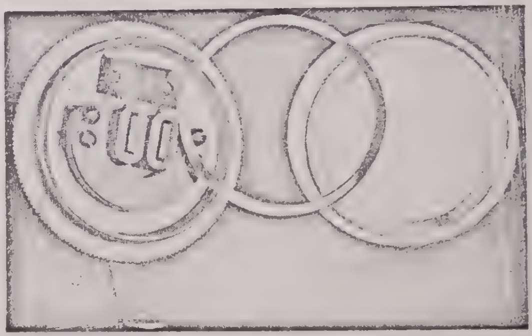


Fig. 9. Construction of Radiola Loud Speaker (Model UZ-1325)

Loud Speakers

The loud speaker is the part of the receiver which transforms the electrical energy into sound energy, and it is this element of the receiver which has offered most difficulty in efforts toward improvement. During the past year there has been marketed a simple standardized reproducer element which is distinctly better in performance than any previously used. Its superiority arises from its capability of reproducing a wide frequency range with reasonable equality of response. A view of the mechanism of its telephone unit is shown in Fig. 9.

Conclusion

Thus it will be seen that broadcast reception has kept pace with the conditions imposed by present-day broadcast transmission, and that the substantial improvements made in 1924 have gone far toward meeting the essential requirements of the user, i.e., selectivity, sensitivity, and quality of reproduction.

Conductorless Electric Circuits

By F. B. Vogdes

Research Laboratory, General Electric Company

We are accustomed to think of electric circuits as depending very definitely on conductors of one kind or another. In this article the author puts the matter in a new light by demonstrating that the familiar electrical conditions of a circuit can exist when the conductors are composed of nothing more tangible than space. The discussion takes us into a study of electromagnetic waves and offers an explanation of the fact that a "wireless" antenna radiates a very considerable percentage of all the power put into it, while a transmission line radiates practically none.—Editor.

Types of Circuits

If we have a heating unit, an electric lamp, or an electroplating bath, it is obvious that the nature of the conductor and the molecular processes which go on inside of it are of first importance; in fact, they are the reason for the usefulness of the device. In electrical machinery, such as motors and transformers, however, the nature of the materials used can be considered of secondary interest. The factors of primary value are their dimensions and arrangement. If perfect conductors and insulation, and iron with no hysteresis, were available, it would be possible to carry a transformer of any rating in one's vest pocket and the only limitation on reduction of the size of motors and generators would be a failure of the mechanical parts, such as the shaft.

An electrical device showing even more clearly the usefulness of the proper arrangement of conducting and non-conducting materials is the radio circuit. A large portion of all the different radio circuits may be represented as in Fig. 1. A condenser and an inductance coil are connected together and free oscillations are produced in them and sustained by a driver of some sort. The energy supplied by the driver is dissipated at the same rate by a load which may take various forms. The power-factor of such circuits is always very low, quite frequently less than five per cent, so it will be seen that the electrostatic field of the condenser and the electromagnetic field of the coil are of greatest consequence. Both fields involve the space surrounding the conductors rather than the material inside of them, and hence the surfaces of the conductors which bound these two fields are of greater importance than the conductors themselves. This raises the question of whether circuits can exist without the aid of conductors to bound the electrostatic and electromagnetic fields. The answer can be found in the work of Clerk Maxwell,(1) but before advancing to it let us consider our oscillating circuit more in detail.

Energy Storage in Oscillating Circuits

An outstanding feature of oscillating circuits is the energy which they store. This energy is constant in amount but the manner in which it is stored varies periodically. At one instant the condenser will be charged to its peak value, the current through the inductance will be zero, and all the energy will be stored in the electrostatic field of the condenser. A quarter of a cycle later there is no charge on the condenser, the current through the inductance is at its peak, and its electromagnetic field contains all the energy. At all other times, the energy is divided between the two fields. This phenomenon of energy interchange and storage is not limited to oscillating electric circuits, but is a general property of all oscillating systems wherever found in nature. The kinetic energy stored in a pendulum at the bottom of its swing is changed to potential energy as the end of the swing is approached, and this potential energy is later utilized in reproducing kinetic energy on the return swing.

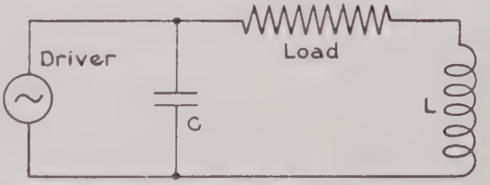


Fig. 1. Schematic Representation of a Common Form of Radio Circuit

Nature of Conductorless Circuits

Since all sources of electromotive force, as we usually think of them, and all resistance, will be eliminated from our discussion by the removal of conductors, it will not be unnatural to turn to oscillations involving electrostatic and electromagnetic fields for an explanation of the nature of conductorless circuits. It is obvious that we still have the two ways of

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(1) "Treatise on Electricity and Magnetism."

storing energy in space and the question now centers on the means by which a change of the amount of energy in one form occurs simultaneously with an equal and opposite change in the amount of energy in the other form.

It is not difficult to believe that a change in the electromagnetic flux linking any circuit induces a voltage in that circuit whether the circuit consists of a conductor or only of dielectric. Take for example the flux in the core of a transformer. It links the turns of the windings and induces voltages in them; it also links a circuit consisting of a closed strip of space lying next to the core and encircles it in the same manner as the windings. It induces a voltage in the latter circuit as well as in the former and this voltage appears as an electrostatic field which could be detected if sufficiently sensitive apparatus were available. In this manner the electromagnetic field can react on the electrostatic field.

It is more difficult to see how changing the electrostatic field can produce a similar effect on the electromagnetic field. To study the electrostatic field in detail, it may be represented by drawing in the lines of electrostatic force as in Fig. 2 which represents a section through the field between two long conductors. Besides the lines of electrostatic force we may indicate surfaces perpendicular to those lines. The potential is the same throughout each of these surfaces and if we place a thin conducting sheet in one of them, as for example through the points *A A′*, it will not distort the field. This method of following equipotential surfaces is often used in designing the skirts of high-tension insulators. Our conducting sheet will have equal and opposite charges induced on the two sides as an equal number of the lines of electrostatic force will end on each side.

If now the field varies in intensity, these charges will vary in magnitude and this represents a current through the sheet. Maxwell assumed that not only did the currents thus produced flow through the sheet, but that "displacement currents" of the same magnitude flowed through the space next to the sheet when the field was changed, and furthermore, that these currents could produce a magnetic field just the same as though they were in conductors. These currents would, of course, be proportional to the rate of change of the field and thus the electrostatic field could react on the electromagnetic field by the same sort of law as governed the action in the other direction.

After calculating the magnitude of the electromagnetic field produced in this manner, Maxwell decided that it was too small to be determined by direct experiment and left his assumption to be verified by the results its introduction into his theory might produce. On this basis he worked out his well-known theory of electromagnetic waves(2) and proved that they had the properties of light. To attempt a comprehensive discussion of his work would be out of place in this article, but we may see the nature of his results by considering a very special and limited case.

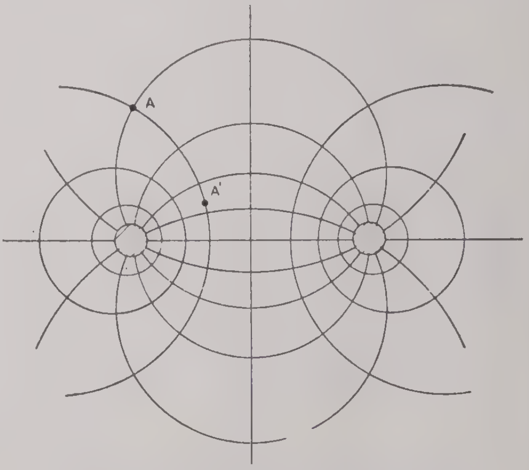

Fig. 2. Electrostatic Field Between Two Parallel Wires

Plane Polarized Standing Electromagnetic Waves

Let us assume an electromagnetic field of infinite extent and an electrostatic field at right angles to it. Fig. 3 represents a portion of these fields.

The direction of the electromagnetic field we shall take as parallel to the surface of the paper and the electrostatic field as perpendicular to it. Both fields vary sinusoidally with respect to time and if the diagram may be taken as representing the peak values attained, they vary sinusoidally reading from left to right but are constant as we move along a line perpendicular to the paper. The fields are separated in phase by 90 deg. with respect to space and also by 90 deg. with respect to time.

Let us see what these two displacements mean physically. The quadrature displacement with respect to time means that when one field is a maximum the other is zero, and indicates the swing of the energy from one form to the other. The quadrature displacement with respect to space means that the two fields link each other. That is, each line of force of either field may be assumed to cross the opposite field and join a line running in the return direction in the next group. This is indicated schematically by the dotted lines connecting the lines of force *A* and *A'* together. It is simplest to consider all lines as passing around the opposite field at an infinite distance. This, of course, is not a true picture but leads to no error as we may assume that both the fields weaken very gradually as we go away from the portions we are considering, this weakening being accomplished by the occasional crossing over of some of the lines of force. In any section of the picture the irregularities will be so slight that they may be neglected and hence we may consider such a section as part of a uniform field of infinite extent in which the crossovers are accomplished at an infinite distance by some means which we need not consider.

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(2) The term "electromagnetic waves" may be misleading. Such waves contain both electromagnetic and electrostatic fields. Where the expression "electromagnetic waves" is used both fields are referred to; where "electrostatic field" or "electromagnetic field" is used only that particular field is referred to, as in the preceding paragraphs of this article.

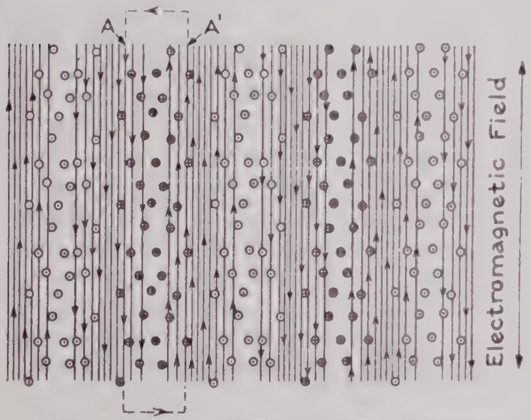


Fig. 3. Arrangement of Fields in a Simple Standing Electromagnetic Wave. The electrostatic field is represented as perpendicular to the paper

We can see now that when either field changes it produces a field of the opposite kind with the correct distribution in space, but not necessarily the correct magnitude. If we can determine that in this arrangement the fields will also have the correct relative magnitudes our solution will be complete. This we may accomplish by considering the rate at which the fields are to change. Let us hold the electromagnetic field constant in amplitude and vary the frequency, starting from zero. The electrostatic field which it produces will be proportional to the frequency and this electrostatic field will finally reach the magnitude necessary to provide by its variation the magnetomotive force to cause the assumed electromagnetic field. This then gives all the requirements for the oscillations to exist. If we work out all the mathematics involved, it appears that the product of the wavelength by the frequency of oscillation per second gives us a distance of 3×10^8 meters or 186,000 miles. This is the distance which light travels per second and all that is necessary to make our fields appear to move along is to superimpose upon them a similar set of oscillatory fields differing from them by 90 deg. in space phase and 90 deg. in time phase. A disturbance of constant magnitude will then appear to move along with the velocity of light just as the magnetic field of a polyphase machine appears to rotate.

Light, heat, and wireless waves are all generally believed to be electromagnetic waves. Wireless waves are comparatively simple, but heat and light waves are very complex. The axes of the fields of the two latter types of waves change as they advance; the wavefronts are more apt to be spherical than plane; and the energy is frequently distributed over an infinite number of wavelengths with only an infinitesimal amount of energy in each wavelength. However, the limited problem which we have solved will serve to indicate the possibility and nature of the general solution and shows that complicated electromagnetic disturbances in space follow the same laws as disturbances in ordinary circuits, and differ from them only because the form and dimensional limitations imposed by ordinary circuits have been removed.

Some Applications to Present-day Problems

The foregoing ideas will clarify several interesting problems. They will indicate, for instance, why we should expect very little energy to be lost by radiation from power lines whereas "wireless" antennas of much smaller size radiate a considerable percentage of the energy. Let us picture the process of radiation from an ordinary circuit as being accomplished by the coupling of its electrostatic and electromagnetic fields with conductorless circuits in the surrounding space. The effectiveness of this coupling will depend on the average strength of the fields over a space comparable in dimensions with the wavelength of the waves radiated. At 60 cycles this distance will be over 3000 miles and the average field strengths due to power

lines at any such distance are extremely small. With radio antennas the case is different; here the wavelength is so short that high average values of the fields will be obtained. Hence the power line will radiate practically no energy but the radio antenna will.

It will also be seen that there is very little hope for the successful wireless transmission of power for, even if the required energy could be transferred from ordinary circuits to conductorless circuits in space, it is difficult to conceive of any apparatus capable of collecting it again. The ordinary radio receiving antenna recovers from space only an extremely small amount of the energy in the waves.

The Completely Arc-welded Barge *Independent*

By W. L. Warner

Industrial Engineering Department, General Electric Company

For several years arc welding has been progressively applied to various details of ship construction as a substitute for riveting. The success of these instances, coupled with that which it has long established in land service, is at last convincing ship builders that the arc weld is a construction they can adopt without fear of departing from their justifiable caution concerning human life. This has led to the building of what we believe to be the first completely arc-welded vessel in America. The barge, described in the following article, was constructed without rivets at a cost far less than that of a similar riveted vessel. Owing to its having been completed but a few weeks ago, no data are available as to its performance in service; yet an index of its strength is already known for it successfully withstood, at the time of its launching under very unfavorable conditions, stresses that probably exceed those it will encounter in service.—Editor.

The application of arc welding to the construction of ships has been receiving attention from ship builders ever since the World War, but to the Saxe Providence Boiler Works of Providence, R. I., goes the credit for building and launching the first completely arc-welded boat in America. This boat will be used by the Pennsylvania Petroleum Products Co. for transporting oil between Fall River, Mass., Providence, R. I., and New Bedford, Mass.

The boat is 76 ft. long, 21 ft. wide, and the deck is 11 ft. above the keel. Work was started in May, 1924, and the completed barge was launched in December with appropriate ceremonies. Arc welding was used throughout in place of pins and rivets. The largest number of men used at any time was six; and the builder estimates that, had the barge been rivet-constructed, a force of eighteen men would have been required.

Fig. 1 shows the construction of the bottom with welders working on the keelsons. The hull is constructed of $\frac{3}{16}$-in. plates joined by two fillet lap welds as shown in Fig. 5. The ribs shown in Fig. 1 are 3-in. by 3-in. by ¼-in. iron angles spaced 22 in. apart and are tack welded on both the toe and heel sides by 4-in. tack welds 8 in. apart.

The barge is built around two cylindrical tanks of riveted-welded construction, which were purchased from the Adamson Mfg. Co. These are 8 ft. in diameter and 67 ft. long, and together have a capacity of 52,000 gal. of oil. Each tank is supported throughout its length by a keelson 16 in. deep, running the length of the barge. In addition to this keelson there are five double-saddle foundations acting as cradles in which the tank rests. These cradles can be seen in Fig. 1. The total weight of the tanks and barge is 70 tons.

The barge is divided into four compartments by three watertight bulkheads (Fig. 2). In Fig. 6 is shown the manner of attachment of each of the bulkheads to the shell of the tanks. Oil will be carried in the two middle sections of the hull around the outside of the tanks. The end sections will be reserved as air compartments for buoyancy.

There are four manhole chambers, of 24 in. diameter, running through the deck from each of the tanks as shown in Fig. 8. Angle ring collars are welded to the deck to support the manhole casings. These manhole chambers allow for the expansion of the oil and also afford easy entry to the tanks for cleaning.

The deck beams are 2-in. by 2-in. by ¼-in. angles and are braced to the tanks with No. 10 gauge steel plates. All seams between the deck plates are welded watertight,

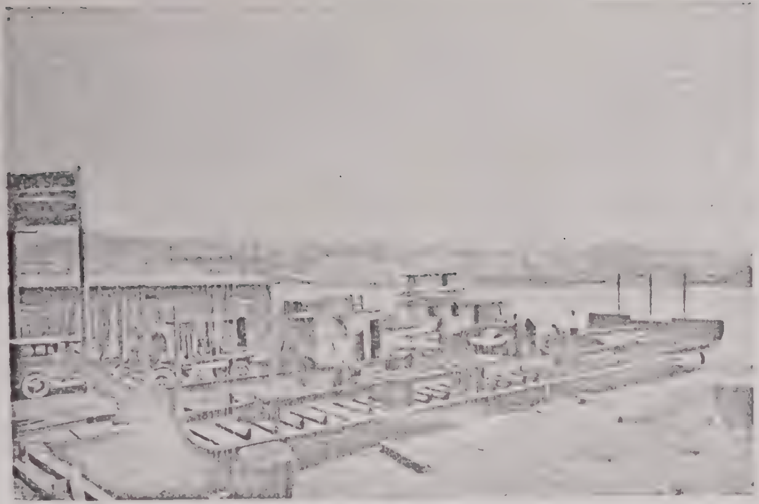


Fig. 1. Completing the Bottom of the Hull for the All-welded Barge

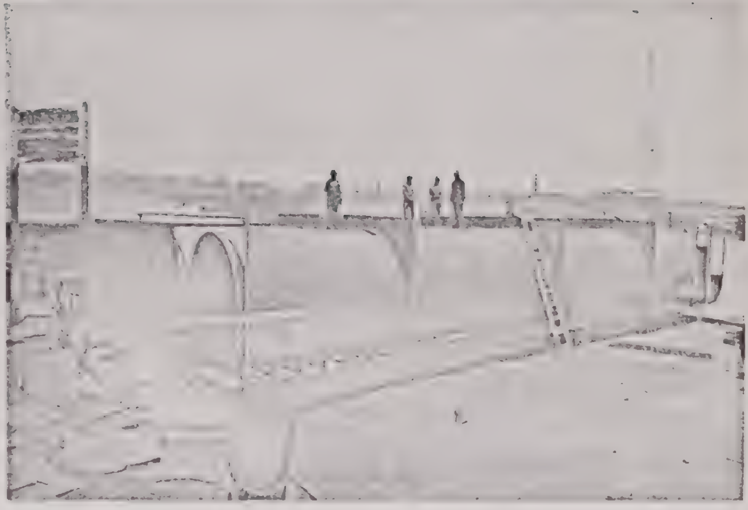


Fig. 2. Barge with Tanks and Cross Bulkheads in Place

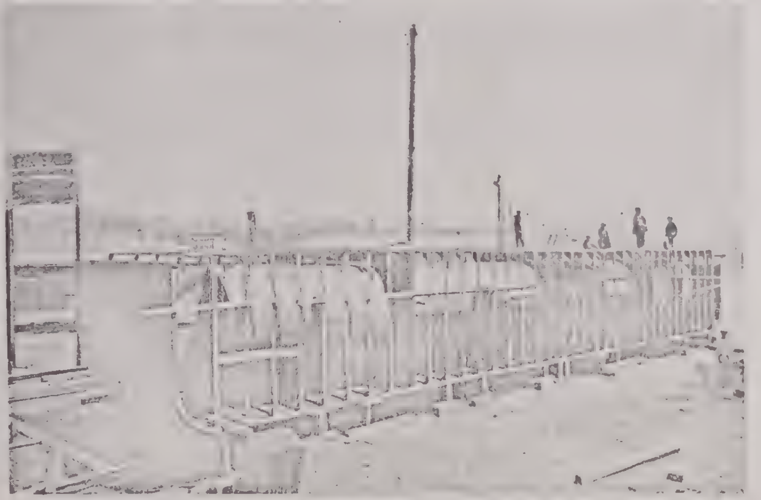


Fig. 3. All-welded Barge with Hull and Deck Framework in Place

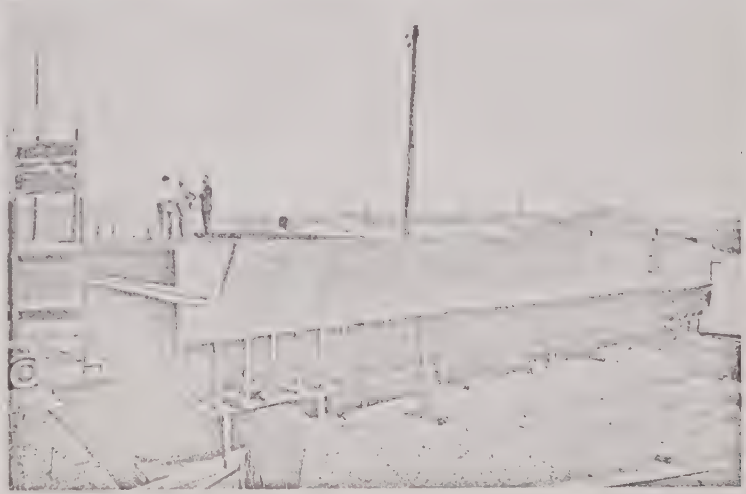


Fig. 4. Barge with One Row of Side Plates Assembled

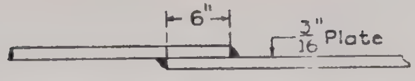


Fig. 5. Lap Welds on Hull Plates

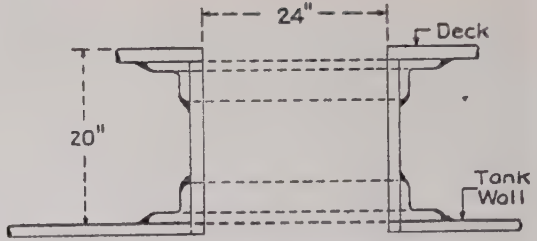


Fig. 8. Cross-section of Manhole Chamber

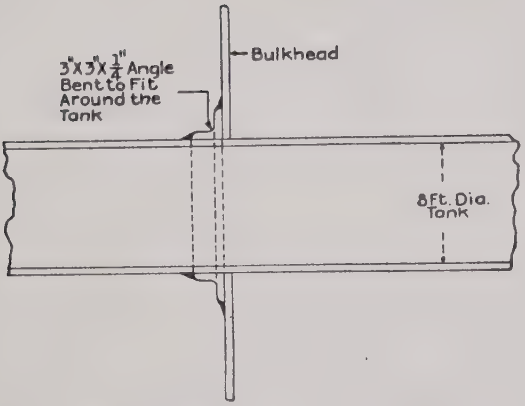


Fig. 6. Attachment of Transverse Bulkheads to the Tanks

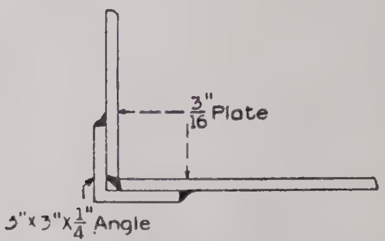


Fig. 9. Details of Joint at Corners of the Hull

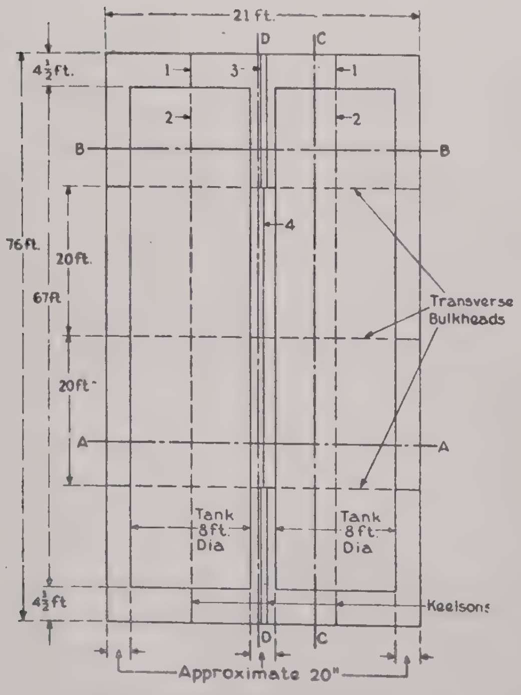
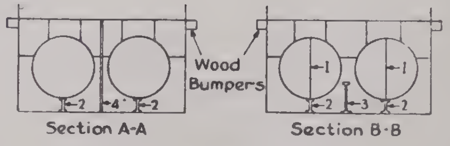
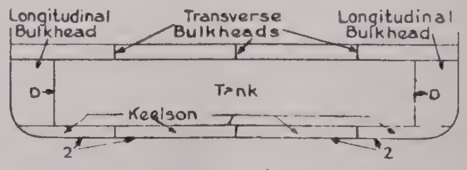


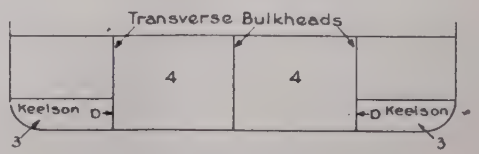
Fig. 7. General Plan of Welded Barge



Cross Section of Barge



Section C-C



Section D-D
Longitudinal Section of Barge

Fig. 10. Sections of Welded Barge at Places Indicated in Fig. 7

preventing any washing of water into the hull. The hull framework may be plainly seen in Fig. 3. An angle iron is welded onto the outside of the hull plates at the corner of the hull as shown in Fig. 9.

Fig. 7 shows a general plan of the barge. The bulkhead *1* may be noted in Fig. 3 at the end of the tank in the foreground, and keelson *2* may be seen under the tank. Keelson *3* (also shown in Fig. 1) is 27 in. deep and extends through only the two end compartments. In the two middle compartments there is a longitudinal bulkhead *4* extending from the bottom of the barge to the deck. This bulkhead acts as another keelson. Sections of the barge at various points are shown in Fig. 10.

A wooden bumper extends around the barge as indicated in Fig. 10. The bumper is a 6-in. by 8-in. pine timber bolted to the hull and supported at the top and bottom by 3-in. by 3-in. angles welded to the hull plates. Fig. 4 shows the laying of the side plates.

There is a deck railing extending around the barge as shown in Fig. 11. At one end is located a deckhouse consisting of two rooms for one occupant, whose duty it is to attend to the hawsers, tow-lines, and various other details of operation. The towing bitts are located two at each end of the barge and are fastened to the tanks, thus avoiding any concentrated towing strain on the hull.

The Saxe Providence Boiler Works, which built the barge, has been engaged in the construction and repair of tanks for 14 years. In this work the company is now using arc welding almost exclusively, the welding equipment consisting of three stationary motor-generator sets(1) and one gas-engine set.(2) In the construction of the barge, two of the motor-generator sets and the gas-engine set were employed.

When the plates for the bottom of the hull were laid and the announcement made that the barge was to be built without rivets or bolts, many persons came to inspect the work. In the opinion of the seafaring visitors, the barge would break in two when launched. As the work progressed however and further visits were made, the attitude changed until skepticism was replaced by enthusiasm. A keen interest has been expressed unofficially in government circles and a government hull inspector stated that this is the nearest approach to a non-sinkable ship he has ever seen.

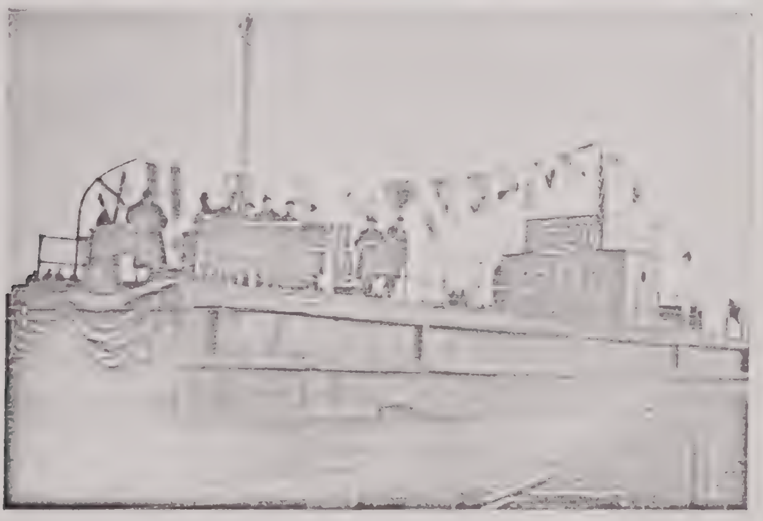


Fig. 11. The Completed Barge Preparatory to Launching

From Fig. 1 it will be noticed that the barge was constructed at some elevation above the surface of the water. For this reason it was necessary to build inclined launching ways from the end of the skids to the surface of the water. Then the shoreward end of the skids was jacked up until the skids were in line with the ways, after which the blocking was knocked out and the barge slid into the water. The launching took place on Saturday morning December 13, 1924. The completed barge is shown in Fig. 11.

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(1) Identified by the trade designation WD-9.

(2) Identified by the trade designation WD-10.

The building and launching of this barge has demonstrated some very interesting facts about electric arc welding and has aroused great interest in one-piece ship construction.

First: The flexibility of the process offers opportunity for simplified construction and for easily making changes or alterations which were unforeseen when the plans were made. For instance, the attachment of the bulkheads to the tanks could have been made only at considerable cost and delay if riveted construction had been used. In fact, this work would have been very difficult to accomplish satisfactorily by riveting. Again, for riveted construction, detailed drawings showing rivet holes and connections would have been necessary. In the present case no drawings were necessary and none were used. The plates and other parts were cut to fit on the site by the oxy-acetylene torch and welded in place. Thus changes or alterations can be made with little delay and expense.

Second: The cost of construction is much less than when riveting is used, as may be noted from the comparison of daily costs shown in Table I.

TABLE I

RIVETING	
Labor: 18 men at an average of 80¢ per hr. for a 9-hr. day	$129.60
Rivets: one keg per day	7.00
Air compressor: running cost	5.00
	$141.60

WELDING	
Labor: 3 electric welders at 90¢ per hr. for a 9-hr. day	$24.30
1 gas cutter and 2 fitting-up men at 90¢ per hr. for a 9-hr. day	24.30
Oxygen: 500 cu. ft. at 2¢ per ft.	10.00
Acetylene: 50 cu. ft. at 4¢ per ft.	2.00
Gasoline-electric welder: running cost	5.00
Power for two motor-generator welders: 50 kw-hr. per day at $0.0746	3.73
	$69.33

It should be stated that fuel and labor charges for rivet heating, laying out, and punching are partly balanced by the cost of electrode material consumed in the welding process. Actually about 2¾ tons of electrodes $\frac{5}{32}$ in. in diameter and 14 in. long were consumed in building the barge. Of this amount it is expected that approximately 2 tons of metal is actually in the welds. Thus, it will be seen that, excluding the costs common to both processes, two vessels could have been built by arc welding for the price of one by riveting.

Third: The joints throughout are water tight when made and therefore no caulking of rivets and seams is required.

Fourth: The completed structure is one solid piece and there is no opportunity afforded for the loosening of seams since the working of plates is impossible.

The construction of this boat was a new venture for Mr. Saxe and he surely deserves commendation for his faith in the arc welding process and its satisfactory application to ship construction.

LIBRARY SECTION

Condensed references to some of the more important articles in the technical press, as selected by the G-E Main Library, will be listed in this section each month. New books of interest to the industry will also be listed. In special cases, where copy of an article is wanted which cannot be obtained through regular channels or local libraries, we will suggest other sources on application.

Car Lighting

Efficient Bus Lighting. Porter, L. C. and Roy, A. C.
Elec. Rwy. Jour., Nov. 29, 1924; v. 64, pp. 922-923.
(Abstract of a paper before the Illuminating Engineering Society.)

Cars, Electric

Articulated Car. Gove, W. G.
Elec. Rwy. Jour., Dec. 6, 1924; v. 64, pp. 963-966.
("A résumé of existing designs of this type of car for surface line, rapid transit and railroad service." Abstract of a paper before the N. Y. Railroad Club.)

Electric Current Rectifiers

Automatic and Semi-automatic Mercury Vapour Rectifier Substations. Rogers, G.
Engng., Dec. 5, 1924; v. 118, pp. 782-784.
(Abstract of a paper read before the Institution of Electrical Engineers. Serial.)

Electric Drive—Marine Auxiliaries

Electric Cargo Winch for Shipboard Service. Loomis, A. O.
Elec. Jour., Dec., 1924; v. 21, pp. 568-573.
(Also in *Pacific Marine Review*, Dec., 1924, pp. 638-641.)

Electric Furnaces

Vitreous Enameling with the Electric Furnace. Collins, E. F.
Fuels & Fur., Dec., 1924; v. 2, pp. 1273-1274.
(Notes on the advantages of the electric furnace.)

Electric Transmission

Interconnection of Power Systems in the Southeastern States. Mitchell, W. E.
A.I.E.E. Jour., Dec., 1924; v. 43, pp. 1150-1153.
(Abridgment.)

Electric Transmission Lines

Corona Loss Tests on the 202-mile 60-cycle 220-kv. Pit-Vaca Transmission Line of the Pacific Gas and Electric Company. Wilkins, Roy.
A.I.E.E. Jour., Dec., 1924; v. 43, pp. 1109-1116.
(Abridgment.)

Electrical Machinery—Parallel Operation

Parallel Operation of Auxiliary Generators. Seeley, H. B.
Power Pl. Engng., Dec. 15. 1924; v. 28, pp. 1257-1260.

Electrical Machinery—Temperature

Multiple-Path Radial Ventilation of Large Turbo-alternators. Ross, M. D.
Elec. Jour., Dec., 1924; v. 21, pp. 540-545.

Electrical Machinery—Testing

Making Electrical Machinery Tests in Industrial Plants. Housley, J. Elmer.
Power, Dec. 2, 1924; v. 60, pp. 890-891.

Electricity—Applications—Domestic

Servicing Domestic Electric Refrigerators. Young, H. E.
Elec. Wld., Nov. 29, 1924; v. 84, pp. 1149-1152.
("Experience data for 224 installations.")

Feed Water Treatment

Purification of Feed Water Containing Oil. Joos, C. E.
Power Pl. Engng., Dec. 15, 1924; v. 28, pp. 1244-1247.

Insulators

Suspension Insulator for High-voltage Systems. Miner, D. F.
Elec. Jour., Dec., 1924; v. 21, pp. 560-564.
(An illustrated account of the work of Prof. H. B. Smith, of Worcester Polytechnic Institute, in developing a new type of insulator.)

Nozzles

Turbine Nozzle Loss Analyzed by Air-flow Measurement.
Power, Dec. 2, 1924; v. 60, pp. 875-877.

Power-factor

Localized Correction of Power-factor. Marbury, R. E.
Elec. Jour., Dec., 1924; v. 21, pp. 583-586.

Machine Cuts Power Costs and Saves Copper.
Coal Age, Dec. 11, 1924; v. 26, pp. 829-830.
(On the use of the asynchronous-synchronous motor for power-factor correction in mines.)

Practical Ways to Correct Power-factor. Dwight, H. B.
Elec. Wld., Dec. 6, 1924; v. 84, pp. 1199-1200.

Railroads, Electric—History

Forty Years of *Electric Railway Journal*.
Elec. Rwy. Jour., Dec. 6, 1924; v. 64, pp. 947-954.
(Although primarily a historical sketch of the periodical, contains considerable matter on the early development of the electric car.)

Railroads—Electrification

New System of Main Line Electrification. De Verebely, L.
Engr., Dec. 5, 1924; v. 138, pp.630-633.
(Illustrated description of a system employing a phase converter type of locomotive, as adopted for the Hungarian State Railways.)

Railroads—Electrification

Spanish Northern Railway Electrification.
Rwy. Elec. Engr., Nov., 1924; v. 15, pp. 386-390.
(General description of the project.)

Ship Propulsion, Electric

Comparison of Diesel-electric and Direct Diesel Propelling Equipments. Thau, W. E. and Coleman, H. C.
Pacific Mar. Rev., Dec., 1924; v. 21, pp. 632-635.
(See also tabulated comparison on pp. 630-631.)

Substations

Substations for Present-day Requirements. Williams, Leroy C.
Elec. Wld., Dec. 6, 1924; v. 84, pp. 1195-1199.
(Substation design as practiced by the Bureau of Power and Light of the city of Los Angeles.)

Water Turbines

Specific Speed, Its Meaning and Use as Applied to Hydraulic Turbines. Livingston, R. T.
Power, Dec. 2, 1924; v. 60, pp. 880-882.

NEW BOOKS

Applied Electricity for Practical Men. Ed. 2 Arthur J. Rowland. 443 pp., 1924, N. Y., McGraw-Hill Book Co., Inc.

Calculus for Engineers. Ed. 2. Ewart S. Andrews and H. B. Heywood. 269 pp., 1924, Lond., Scott, Greenwood & Son.

Diesel and Oil Engineering Hand Book, Land and Marine. Ed. 2, enl. Julius Rosbloom. 780 pp., 1924, Los Angeles, Technical Pub. Co.

Electrical Circuits and Machinery. Vol. 2: Alternating Currents. John H. Morecroft and Frederick W. Hehre. 444 pp., 1924, N. Y., John Wiley & Sons, Inc.

(A companion volume to the authors' previous work entitled "Continuous Current Circuits and Machinery". It devotes considerable space to alternating-current theory, especially to voltage and current relations and power measurements in polyphase circuits. A consistent notation scheme has been employed for the representation of vector relations. Chapters on meters, generators, transformers, induction motors, synchronous motors, single-phase motors, rectifiers, and power transmission give due attention to the practical applications of alternating-current.)

Electrical Machinery and Control Diagrams. Terrell Croft. 305 pp., 1924, N. Y., McGraw-Hill Book Co., Inc.

Electrical Measurements in Theory and Application. Ed. 2. Arthur W. Smith. 338 pp., 1924, N. Y., McGraw-Hill Book Co., Inc.

Electricity Supply Costs and Charges. H. M. Sayers. 80 pp., 1924, Lond., Electrical Review, Ltd.

(A small pamphlet presenting a study of the effects of load factor and diversity factor upon the costs of generating electric energy. Considers also such related topics as capital charges, standby costs, distribution costs, and the like.)

Elements of Electrical Engineering. George D Shepardson. 335 pp., 1924, N. Y., Macmillan Co.

Industrial Electricity; Direct-current Machines. William H. Timbie. 735 pp., 1924, N. Y., John Wiley & Sons, Inc.

(Intended for students and electrical workers, and employs no mathematics beyond simple algebra. Explains the generation, transmission and applications of direct-current electricity. The fundamentals, such as magnetism and the magnetic circuit, are presented as a logical introduction to a chapter on generators and one on motors. Armature windings and commutation, inductance, condensers and dielectrics, storage batteries, meters and measurements, and vacuum tubes and gaseous conduction, all receive careful treatment. Each chapter is followed by a condensed summary and a collection of problems to aid the student to a better understanding of the principles set forth.)

Management's Handbook. L. P. Alford (Editor.) 1607 pp., 1924, N. Y., Ronald Press Co.

Principles and Practice of Electrical Engineering. Ed. 3, rev. Alexander Gray. 448 pp., 1924, N. Y., McGraw-Hill Book Co., Inc.

Treatise on Physical Chemistry. 2 vols. Hugh S. Taylor (Editor.) 1359 pp., 1924, N. Y., D. Van Nostrand Co.

(This two-volume work is indicated as being "a co-operative effort by a group of physical chemists." The intention has been that each contributor should cover that portion of the complex subject of physical chemistry which he is particularly fitted, by his training and experience, to expound. To that end each chapter is presented as the distinct contribution of a single author, these chapters, in turn, having been correlated by Dr. Taylor to form a very complete text in physical chemistry. To the advanced student and the research worker in physical chemistry this united effort of seventeen authorities on various phases of the subject should prove of great value. The carefully prepared author and subject indexes make readily available the large amount of information included in the text.)